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PROSPECTS OF FURTHER DECLINE IN MORTALITY RATES *

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SINCE forecasting mortality rates involves a large element of personal judgment, it is not surprising that past forecasts have varied in accordance with the purposes for which they were made. Persons concerned with public health and medicine quite naturally have been interested in the reduction in mortality rates which might be brought about by wider application of current medical knowledge. Perhaps the most noteworthy of the forecasts prepared for this purpose are those published by the Metropolitan Life Insurance Company [1]. Three hypothetical life tables have been constructed, the first in 1922, the second in 1933 and the third in 1941. These were thought to represent, at the time they were prepared, the most likely improvement in the expectation of life to be anticipated from the application of currently existing knowledge.

No time limit was specified for the realization of the improvements indicated by these hypothetical life tables, but subsequent events have

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shown that each of the three forecasts was unduly conservative. The maximum decline in mortality rates projected in 1922 was surpassed, at most ages, by the experience of white females during the decade from 1930 to 1939. The expectation of life for white females shown in the life table for 1948 is almost identical, age for age, with that forecast by the latest hypothetical table constructed in 1941, being slightly higher at the younger ages and slightly lower at the older ages with a maximum deviation of less than one-half year.

The interest in population forecasts stimulated by the rapid decline in fertility rates with the consequent possibility of a stationary or even declining population has led to a series of forecasts of longevity. In contrast to the hypothetical life tables constructed by the Metropolitan Life Insurance Company, those prepared for use in population projections by necessity have indicated the probable accomplishments in the reduction of mortality by specific future dates. The best known of the mortality projections prepared for forecasting population change undoubtedly are those of the Scripps Foundation [2].

These have featured not a single most likely projection but a series of three alternatives: (a) high mortality rates or the least decline that might be expected—rates so high that if the actual death rates in the future were not appreciably smaller most informed persons would consider that a serious set-back in health progress had taken place; (b) low mortality rates or the greatest decline that might be expected under the most favorable conditions—considered possible but not probable; and (c) medium mortality rates which almost inevitably were the projection of choice.

The three series of mortality forecasts have been sufficiently divergent to embrace the actual mortality rates observed to date, but like the hypothetical life tables of the Metropolitan Life Insurance Company they have underestimated the rate of decline. Subsequent events have revealed that the series of low mortality rates, that is, those considered possible but not probable, have been closer to actual experience. Using the latest projections for white females, the expectation of life at different ages forecast for 2000 on the basis of high mortality rates falls below the corresponding values in the 1948 life table; the expectation of life forecast on the basis of medium mortality rates for 1980 approximately equals that of the 1948 table, while the projections for 1960 resulting from the low mortality rates are only slightly more favorable than the actual experience of 1948. For white males and for the nonwhite

population, the actual experience to date has been close to that forecast by the low mortality rates, although it now seems likely that mortality rates for nonwhite females will decline even more rapidly than that assumed by the low mortality rate series.

A third major purpose for which mortality forecasts have been made is the determination of a conservative basis for estimating annuity premiums and reserves by life insurance companies [3]. For this purpose a conservative mortality table is one which shows the greatest possible decline without appearing to be implausible. Moreover, the estimation of mortality rates for persons 60 or more years of age is more crucial than when making projections for forecasting population growth.

THE ARRANGEMENTS OF RATES FOR FORECASTING MORTALITY

In preparing to forecast the future course of mortality rates one is confronted with two fundamental questions: (a) what set of mortality rates shall be used as the basis of the forecast, and (b) how shall the forecast be made? The different ways of arranging mortality rates are illustrated in Figure 1. Calendar date of birth measured from some origin is shown on the vertical axis. Age since birth is shown along the horizontal axis.

Each row represents the experience of a group or cohort of persons born during the same interval of time. Mortality rates along rows thus portray the lifetime or generation experience of persons with a common time of birth.

Each column represents the experience of persons of a fixed age at different intervals of time. The mortality rates along columns form a time series for each age group indicated on the age axis. As such they depict the mortality experience of successive cohorts of persons while passing through the same age group.

The diagonal represents the experience of persons of all possible ages during a specified time interval. The mortality rates for each age group represent the experience of a different cohort. This is the way mortality statistics customarily are tabulated. The usual life tables with which we are familiar are computed from mortality rates arranged in a diagonal as shown in Figure 1.

The hypothetical life tables constructed by the Metropolitan Life Insurance Company were based essentially upon mortality rates arrayed along diagonals. The mortality projections used in preparing the population forecasts of the Scripps Foundation were derived primarily from

rates arrayed in columns, that is, from time series. The recent projection of mortality rates to obtain a new basis for the calculation of annuity functions published by Jenkins and Lew also utilized data arrayed in columns.

Although a number of articles have discussed the merits of analyzing mortality trends from data arrayed in rows, that is, by the generation or

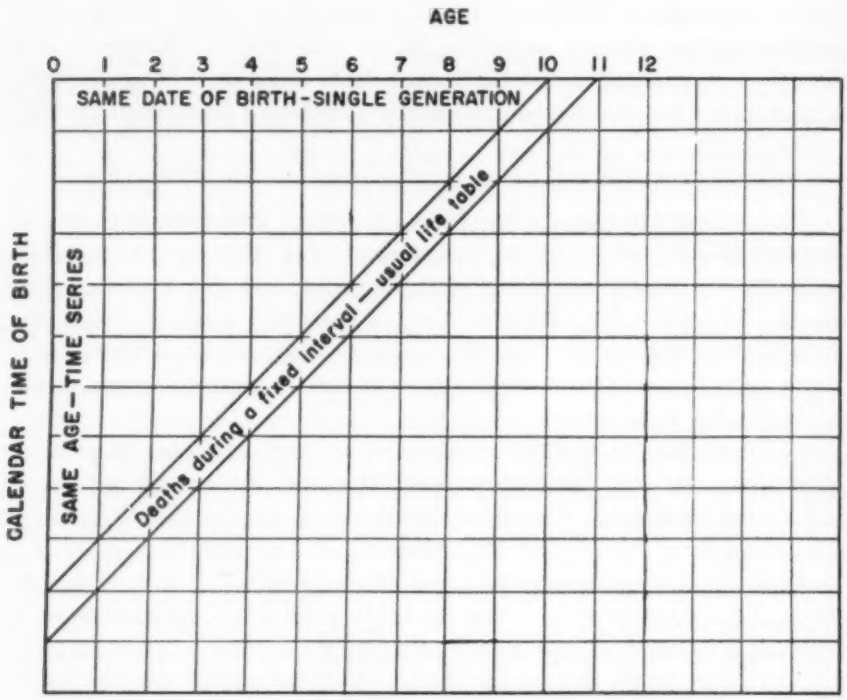
AGE
0 1 2 3 4 5 6 7 8 9 10 11 12
SAME DATE OF BIRTH - SINGLE GENERATION
CALENDAR TIME OF BIRTH
SAME AGE — TIME SERIES
Deaths during a fixed interval — usual life table

FIG. 1. SCHEMATIC REPRESENTATION OF MORTALITY RATES

cohort approach, this method has not been used to any appreciable extent for forecasting future trends [4-7]. The method was investigated by the Royal Commission on Population of Great Britain when it developed mortality projections preparatory to forecasting the population of Great Britain but was rejected because the projected mortality rates for persons in the older groups were unbelievably low.

The essential argument advanced by the proponents of the generation approach is that every generation tends to carry with it throughout its

lifetime a characteristic mortality which is determined primarily by conditions prevailing at the time of birth and which is altered only very slightly, if at all, by improved conditions during later life. If we let t = calendar time, x = age and $F(t, x)$ = the specific death rate for persons of age x at time t, then we may write $F(t, x) = A(t - x)Bx$ where $(t - x)$ is the date of birth. Hence the ratio of the mortality rates at each age of a generation born during time N to the corresponding mortality rates of a generation born during time $N - 1$ should be essentially constant for all age groups.

To forecast the future trend of mortality, it would simply be necessary to compute the ratio, up to the current attained age, of the mortality in each incomplete generation to that of the corresponding age span of some completed generation and then to use this ratio to project the mortality rates for the remaining years of life of the incomplete generation. Unfortunately, complete, reliable mortality data have been available in the United States for too short a time to test the validity of this theory.

METHODS OF PREPARING FORECASTS

In addition to selecting the arrangement of mortality rates, it is necessary also to choose some method of making the projections. The Metropolitan Life Insurance Company's series of hypothetical life tables were computed from mortality rates derived by reducing the age specific mortality rates in the latest life table for New Zealand by amounts which, in the opinion of the authors, appeared reasonable. This amounts to taking mortality rates arrayed along a diagonal in Figure 1 and reducing the rates for the separate age groups by varying amounts. In other words, the projection is based primarily on informed judgment and proceeds immediately from the existing rates to the final projected rates.

At the opposite extreme is the method used by the Royal Commission on Population of Great Britain. Distrusting sole dependence upon qualitative wisdom in forecasting the future course of mortality, the Royal Commission experimented with the extrapolation of several types of curves fitted to age specific mortality rates for the period 1901-1945. The projected rates finally selected were those obtained by the extrapolation of exponential trend curves.

Rejecting the use of mathematical curves to project mortality rates, Whelpton based his forecasts upon a detailed examination of the past trend of mortality rates from all causes and from specific causes of death for the United States and upon a compilation of the lowest death

rates recorded for each age group in any of the 48 states or in any foreign country. The ultimate mortality rates for the medium projection apparently were very close to the lowest rates recorded for each age group in any state or foreign country at the time the forecasts were prepared. The general procedure was to select for native white males a set of ultimate age specific mortality rates to be achieved at some specified future date, the year 2000 for the latest forecast, and to join these to the currently prevailing rates so as to produce a smooth trend. Corresponding rates for other population groups were obtained as varying multiples of the guiding set of rates for native white males.

Jenkins and Lew in preparing their proposed mortality table for annuitants examined the trend in mortality rates for the general population and for a number of insurance populations. From a consideration of these trends and taking account of the opinion of various persons concerning the possibility of a reduction in mortality from specific causes, Jenkins and Lew selected average annual rates of decrease in mortality for each age group. These rates of decrease would continue indefinitely but presumably would be compared from time to time with actual experience to determine whether or not they should be revised.

Two sets of projected rates of decrease were proposed, the second differing from the first by having lower percentage decreases at ages under 60 and greater percentage decreases at ages over 60. The smaller rate of decrease at ages under 60 assumed in the second set was justified by the authors on the grounds that improvements in public health, sanitation, and personal hygiene have nearly attained their maximum effects so that it appeared unreasonable to expect future decreases in mortality at these ages to be as large as those in the past. With respect to the probable future absolute decrease in mortality rates at these ages this assumption is undoubtedly correct. But Jenkins and Lew were projecting relative rates of decline, and there is little evidence that the assumption represents more than a personal opinion when relative rates are considered. Perhaps the reduction in the rates of decrease at the younger ages was partial compensation for the higher rate of decrease assumed for ages above 60.

METHOD OF PREPARING THE PRESENT FORECASTS

The procedure followed in the preparation of the present forecasts is closer to that of Jenkins and Lew than to that used by any of the others mentioned above. The generation or cohort approach was rejected

primarily because complete mortality data have been available for too short a time in the United States either to test its validity or to provide a reliable basis for projection. Neither did it seem profitable to accept the life table of some country with lower age specific mortality rates than those prevailing in the United States and to reduce the mortality rates in this table by some arbitrary amount to obtain a projected life table for the United States at some future date.

The general procedure followed was to start with death rates arrayed in columns as in Figure 1, that is, as time series for each age group. The Royal Commission on Population and Whelpton of the Scripps Foundation both used death rates arrayed in this manner. However, the method of projection employed here differs from that of either of these authors. Mortality rates were projected separately for the four major subgroups of the total population, white males, white females, nonwhite males, and nonwhite females, since both the absolute level and trend of the rates for these groups differ rather appreciably. Annual rates of decrease in the mortality rates at each age for the four subgroups were determined. From these, mortality rates were projected for 1960 and 1970. Possible advances in medicine during the next two decades and the potential effect of these advances upon the level of mortality rates among persons over 50 years of age make projection beyond 1970 rather hazardous.

This method of projection was adopted for the following reasons:

1. The major factors tending to bring about lower mortality rates in the past have been improvements in sanitation, control of communicable diseases by immunization and elimination of environmental conditions favorable to the spread of diseases, improved personal hygiene, better conditions of work, and a general rise in levels of living. Advances in medicine and surgery, apart from preventive medicine, have played a relatively minor role until very recent times.

2. Advances in medicine and surgery during the past 10 to 15 years have become increasingly important as a factor in the decline in death rates due largely to developments in chemotherapy, improvements in surgical skill and technique, widespread use of blood and blood derivatives, more reliable methods for early diagnosis of disease, and more general use of better equipped medical facilities.

3. Unlike the past, the major factor in bringing about large decreases in mortality in the future will be advances in medicine and surgery. This does not mean that the factors operating to bring about lower

mortality rates in the past will not continue to be effective in the future. It is believed, however, that the future decreases in death rates due to these factors cannot equal those of the past over comparable periods of time; consequently, the decrease in mortality rates will tend to become smaller and smaller unless other factors begin to operate.

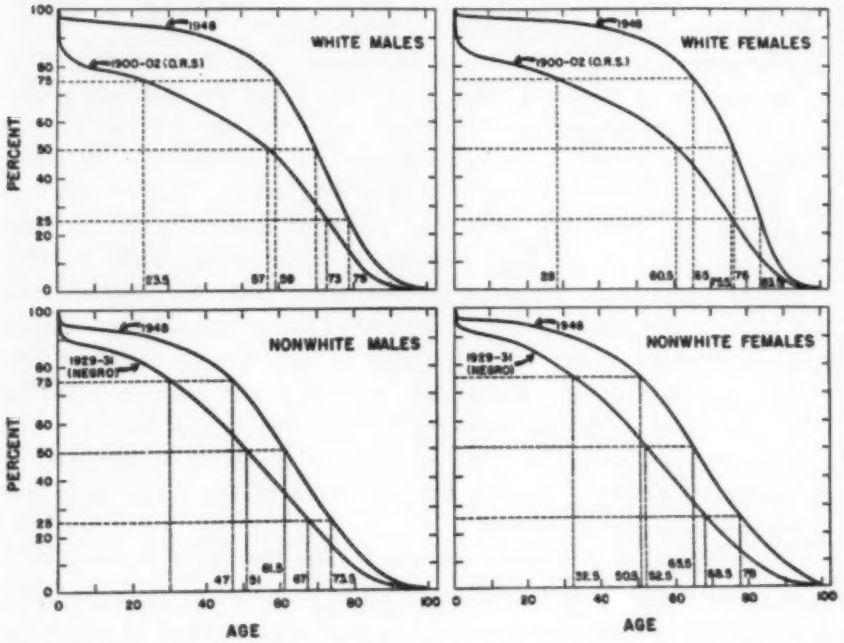

FIG. 2. PER CENT SURVIVING TO EACH AGE OF LIFE TABLE COHORTS, BY SEX AND COLOR, UNITED STATES (FROM TABLES PREPARED BY THE NATIONAL OFFICE OF VITAL STATISTICS)

For these reasons it did not appear desirable to base the projection of mortality rates upon a long time trend in the past nor to assume that a reliable guide for the future could be obtained by taking the lowest death rates recorded at each age in any state or foreign country. These two methods of projection were not neglected, but they were not the determining influence in choosing the assumed rates of decline in mortality rates.

An increase in the expectation of life at birth during the next 20 years comparable to that of the past two decades can be achieved only by an appreciable lowering of mortality rates during the late adult life or the complete elimination of death prior to middle age (Figure 2).

According to the life table for 1948, three-fourths of newborn white males would live until age 59, and three-fourths of newborn white females would live until age 65. Corresponding ages for nonwhite males and females are 47 and 50, respectively. Consequently, the complete elimination of all deaths prior to age 40, a most unlikely event, would increase the expectation of life at birth for both the white and nonwhite populations as recorded in the life table for 1948 by a smaller amount than that which actually occurred during the previous 18 years (Table 1).

TABLE 1

Increase in expectation of life at birth assuming that no deaths occur prior to specified ages

COLOR AND SEX	e_0 FROM LIFE TABLE FOR*		e_0 ASSUMING NO DEATHS OCCUR BEFORE AGE†			
	1929-31	1948	10	20	30	40
White male	59.1	65.5	68.4	69.0	69.8	70.7
White female	62.7	71.0	73.5	73.8	74.3	75.0
Nonwhite male	47.6	58.1	62.1	62.9	64.6	66.8
Nonwhite female	49.5	62.5	66.1	66.8	68.3	70.3

* Computed by the National Office of Vital Statistics.

† Death rates at remaining ages same as in the 1948 life table.

Mortality during the early years of life already is so low that even a continuation of the prevailing relatively large annual rates of decrease will have only a small effect upon the average longevity of the total population.

Large increases in the average longevity of the total population can be achieved only by lowering the mortality rates of late adult life. The possibility of this will be largely determined by the prospects of a decrease in the age specific death rates from accidents, cancer, and cardiovascular-renal diseases (Table 2). After age 50 these three groups of causes account for more than two-thirds of all deaths. What is the likelihood of lower mortality from these causes, particularly during late adult life?

THE OUTLOOK FOR A DECLINE IN MORTALITY RATES

First let us review briefly the trend in age specfic death rates from all causes. These data are presented in Figures 3-7 for the period

1920-48. In general the rate of decrease in death rates has been greater since about 1935 than it was previously. In fact, except for the early years of life, mortality rates for white males and nonwhite males and females either did not decrease or even increased slightly from 1920 to 1930.

TABLE 2

Per cent of deaths from all causes attributed to accidents, cancer and cardiovascular-renal diseases, United States, 1946-48*

AGE	WHITE		NONWHITE	
	Male	Female	Male	Female
Total	72	72	55	58
0-4	8	8	8	8
5-9	58	49	50	48
10-14	67	53	57	40
15-19	75	49	47	22
20-24	70	39	34	19
25-29	62	39	34	26
30-34	59	46	37	38
35-39	60	55	42	50
40-44	63	64	51	61
45-49	68	72	59	69
50-54	73	75	65	74
55-59	76	77	70	77
60-64	78	78	74	79
65-69	81	80	74	79
70-74	82	83	76	80
75-79	83	84	75	79
80-84	85	86	74	77
85 & over	80	82	73	73

* Includes Int. List Nos. (fifth rev.) as follows: accidents, 165-195; cancer, 44b, 45-55, 74; cardiovascular-renal, 58, 83, 90-103, 111a, 131, 132.

During the past 10 years the rate of decrease has been very pronounced during the early years of life for each of the four groups but has become smaller with increasing age. For females, decreases occurred throughout the entire age span up to age 85. For white males the trend has not been so favorable; although death rates during the first half of the life span are now definitely lower than they were 20 years ago,

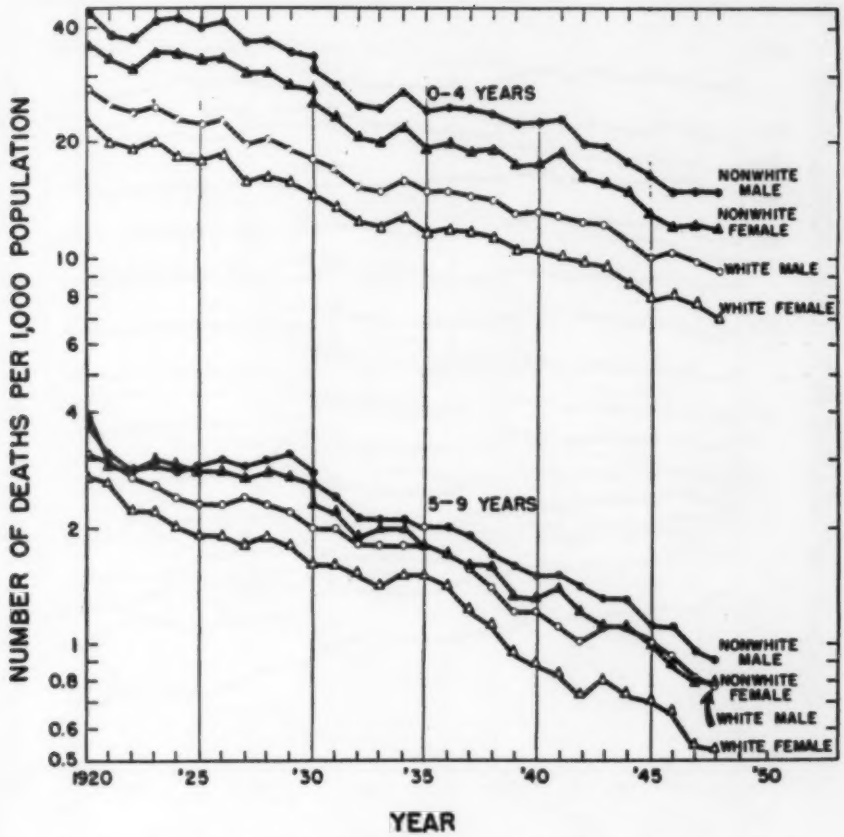

FIG. 3. NUMBER OF DEATHS FROM ALL CAUSES PER 1,000 POPULATION BY SEX AND COLOR FOR AGES 0-4 AND 5-9, UNITED STATES, 1920-1948

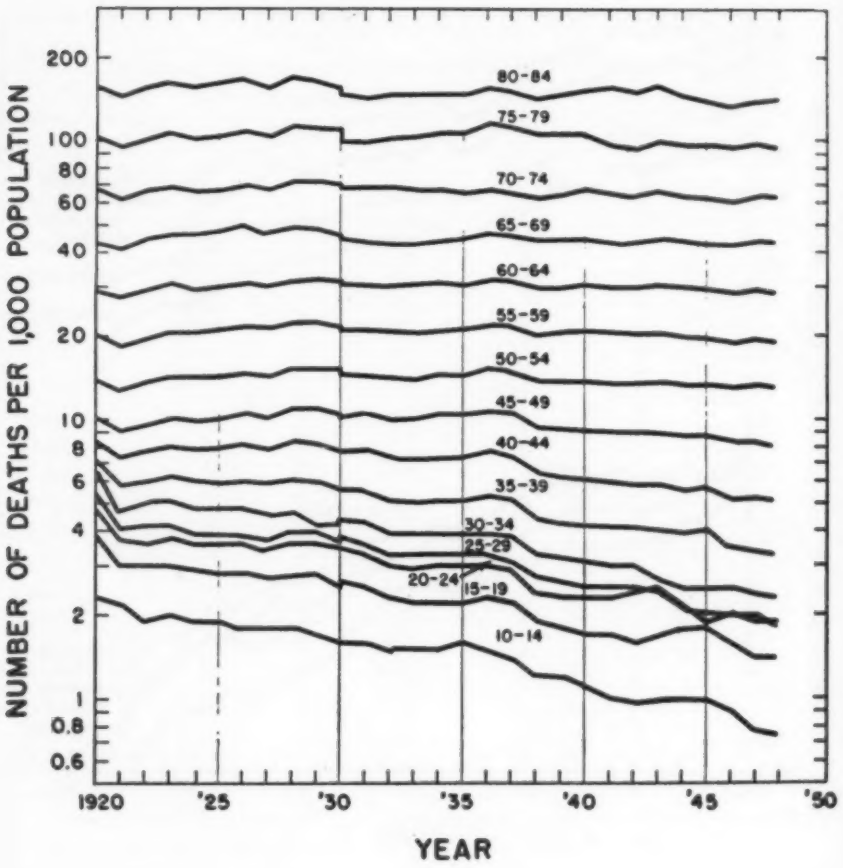

FIG. 4. NUMBER OF DEATHS FROM ALL CAUSES PER 1,000 POPULATION BY AGE FOR WHITE MALES, UNITED STATES, 1920-1948

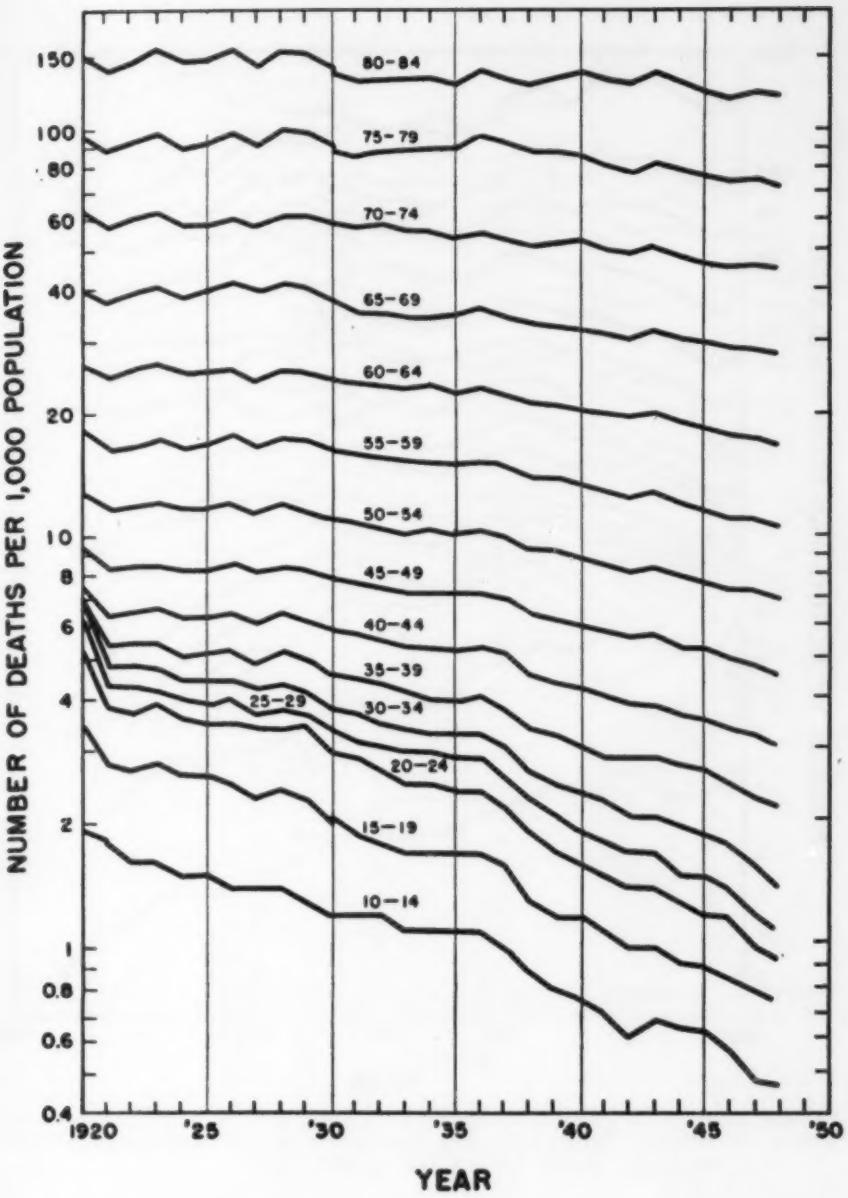

FIG. 5. NUMBER OF DEATHS FROM ALL CAUSES PER 1,000 POPULATION BY AGE FOR WHITE FEMALES, UNITED STATES, 1920-1948

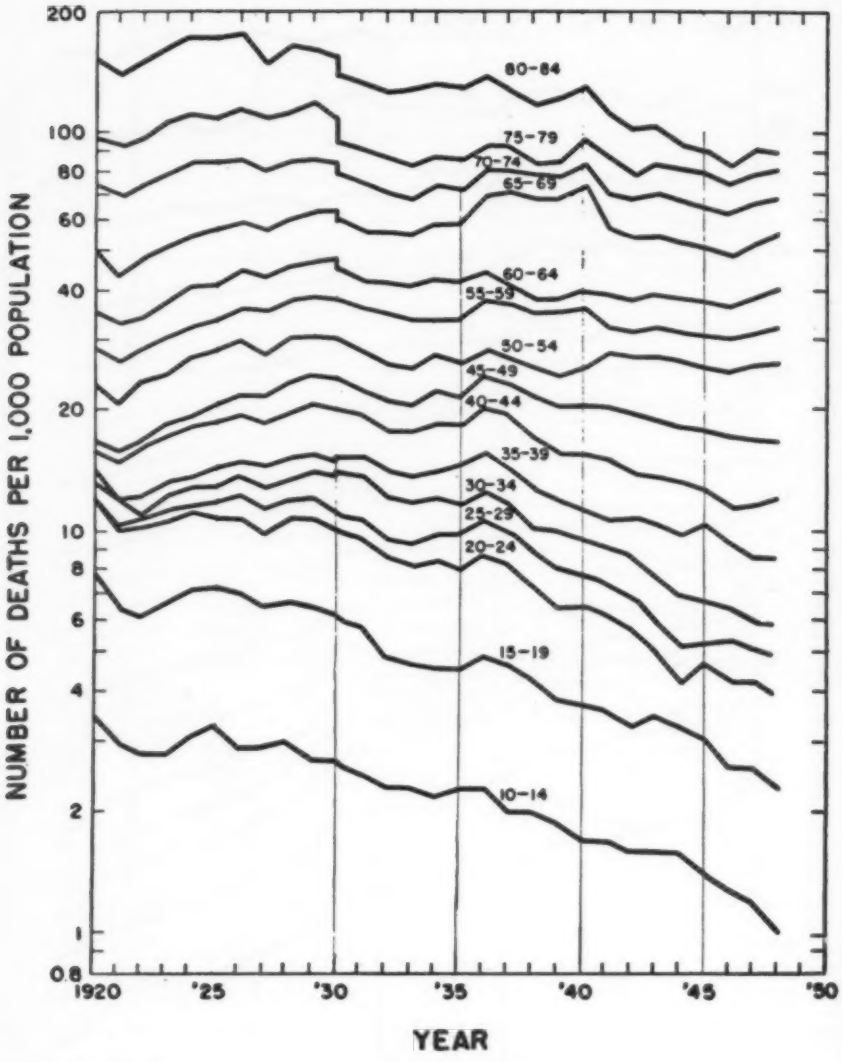

FIG. 6. NUMBER OF DEATHS FROM ALL CAUSES PER 1,000 POPULATION BY AGE FOR NONWHITE MALES, UNITED STATES, 1920-1948

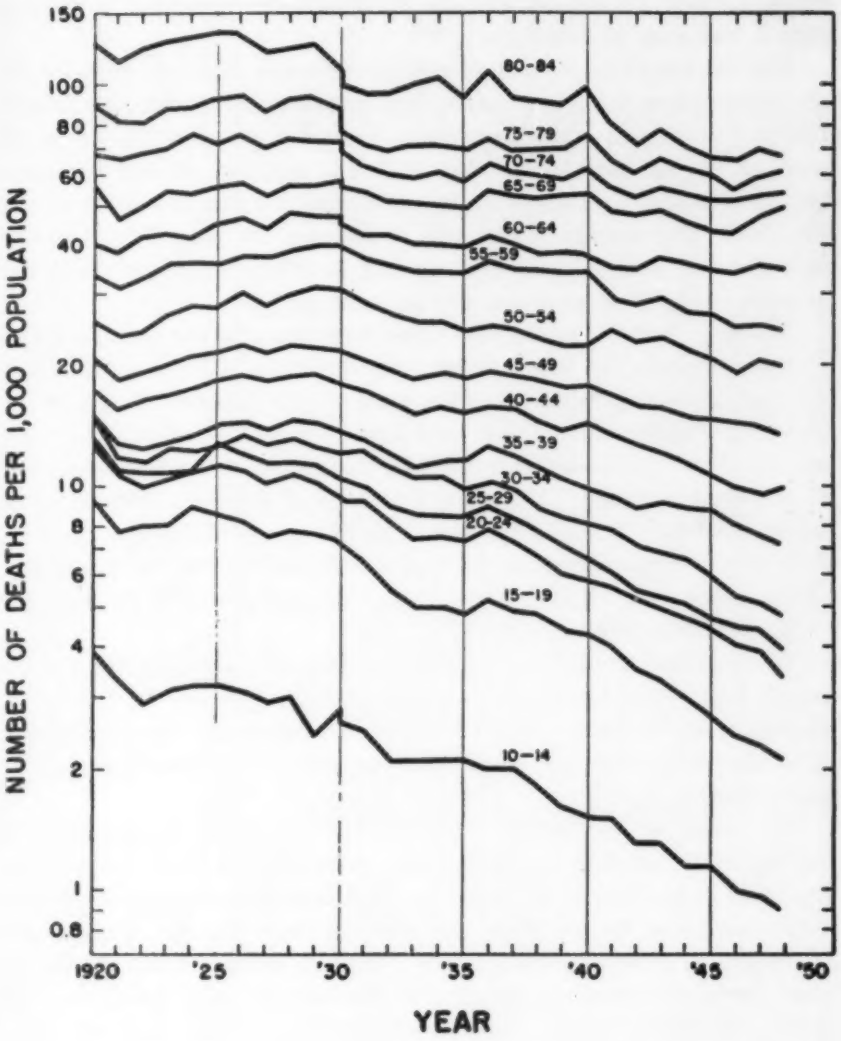

FIG. 7. NUMBER OF DEATHS FROM ALL CAUSES PER 1,000 POPULATION BY AGE FOR NONWHITE FEMALES, UNITED STATES, 1920-1948

decreases in the rates for ages over 60 have been insignificant. As a whole, however, the outlook for each of the four groups is more promising than it was even 10 years ago.

For the nonwhite population definite decreases in death rates for all age groups from accidental causes were recorded during the past decade (Table 3). In the white population, rates for young adults 15 to 24 years of age are now higher than a decade ago, but marked decreases have occurred at ages above 25 except during the last few years of the life span. The average annual rate of decrease has ranged from two to four per cent at ages over 40 except for nonwhite males for whom the decrease has been about one to two per cent per year.

When we turn to the cardiovascular-renal diseases, the outlook is also promising except for white males (Figures 8, 9). While a noticeable decrease in mortality has taken place among white males at ages under 35 years, death rates at older ages have increased steadily during the past 30 years with no indication of any slackening of the increase except at 75-84 years of age. For white females and for the nonwhite population, the trend in mortality rates from this group of diseases has been definitely downward during the past decade except for the age group 85 years and over for white females and the age group 65-74 years for the nonwhite population.

The outlook for an appreciable lowering of mortality rates from cancer during the next few years is not favorable (Figures 10, 11). The most that can be expected is a cessation of the steady increase for the male population with some slight decrease in rates for females, especially white females.

In preparing the present projections, the average annual rates of decline in age specific mortality rates were derived from a review of the trend from 1936-38 to 1946-48. This is roughly the period during which advances in medicine and surgery have become increasingly important in lowering death rates. Average annual rates of change were computed separately by age for the four sex-color groups for all causes, accidents, cancer, cardiovascular-renal diseases, and all other conditions as a group.

CALCULATION OF PROJECTED MORTALITY RATES

Certain irregularities and apparent inconsistencies in the age specific death rates and the observed rates of change were eliminated. For the nonwhite population over 75 years of age, the reported mortality rates

TABLE 3

Number of deaths from accidental causes per 100,000 population by age, sex and color, United States, 1936-38 and 1946-48 with the average annual rate of decrease

AGE	WHITE MALE			WHITE FEMALE			NONWHITE MALE			NONWHITE FEMALE		
	1936-1938	1946-1948	Average annual rate of decrease (per cent)	1936-1938	1946-1948	Average annual rate of decrease (per cent)	1936-1938	1946-1948	Average annual rate of decrease (per cent)	1936-1938	1946-1948	Average annual rate of decrease (per cent)
All ages	111	95	1.5	48	43	1.2	126	106	1.7	44	38	1.6
0-4	74	61	1.9	57	44	2.6	106	97	0.9	97	82	1.6
5-9	42	35	1.8	22	17	2.6	41	37	1.2	33	25	2.8
10-14	43	39	1.0	14	12	1.3	57	50	1.4	17	17	0.0
15-19	79	82	−0.4	21	22	−0.6	105	87	1.9	23	20	1.5
20-24	103	110	−0.6	21	18	1.6	137	105	2.6	25	25	0.3
25-29	92	83	1.1	18	14	2.5	142	110	2.6	29	21	2.9
30-34	89	76	1.6	18	13	2.8	130	106	2.1	27	22	1.8
35-39	97	76	2.4	19	16	1.6	154	119	2.6	34	27	2.3
40-44	105	79	2.8	21	16	2.7	160	133	1.9	36	25	3.7
45-49	121	85	3.5	26	19	3.2	161	137	1.6	43	30	3.7
50-54	144	97	4.0	35	23	4.2	179	149	1.8	58	38	4.1
55-59	163	111	3.9	45	30	4.1	165	149	1.1	61	47	2.6
60-64	188	136	3.2	67	44	4.3	176	170	0.3	88	59	4.1
65-69	229	180	2.4	122	78	4.5	225	186	1.9	122	93	2.8
70-74	279	227	2.1	212	157	3.0	260	224	1.5	163	116	3.4
75-79	434	345	2.4	444	328	3.0	275	243	1.2	180	140	2.6
80-84	622	575	0.8	809	702	1.4	359	261	3.2	251	197	2.4
85 & over	1209	1288	−0.6	1705	1940	−1.3	580	379	4.2	498	292	5.3

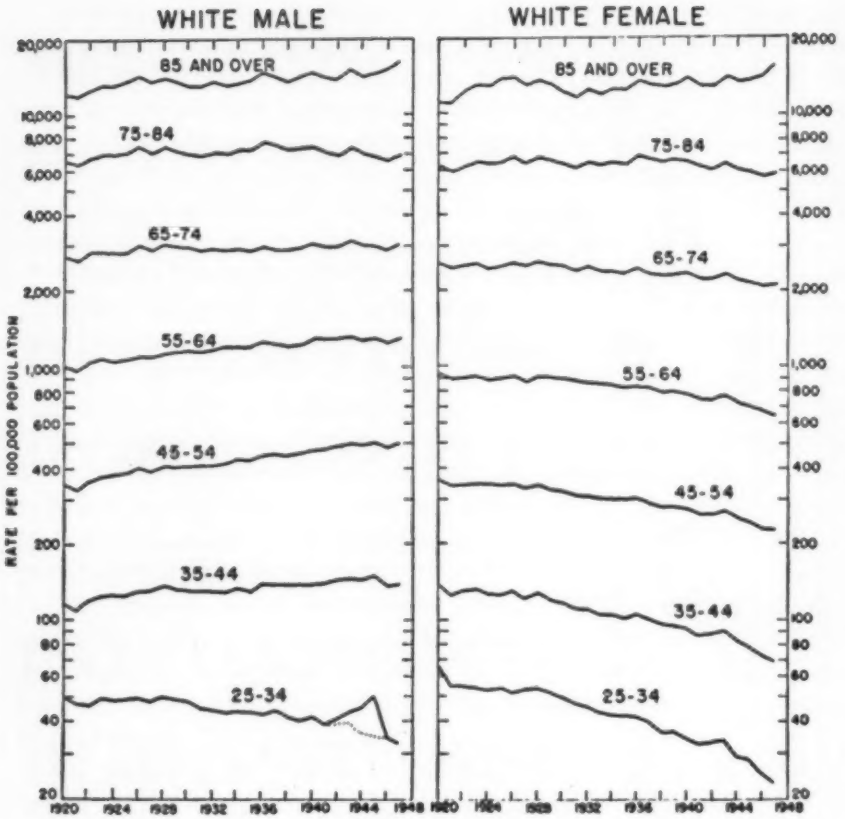

FIG. 8. NUMBER OF DEATHS PER 100,000 WHITE POPULATION FROM THE MAJOR CARDIOVASCULAR-RENAL DISEASES BY AGE AND SEX, UNITED STATES, 1920-1947 (REPRODUCED FROM *Public Health Reports*, MARCH 23, 1951, PAGE 360)

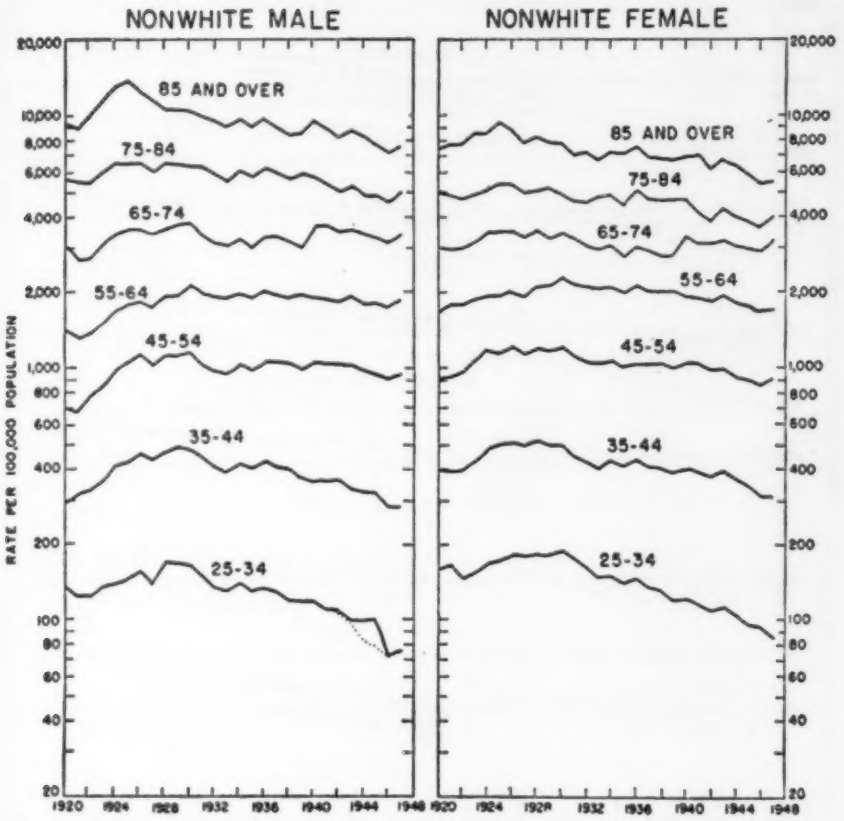

FIG. 9. NUMBER OF DEATHS PER 100,000 NONWHITE POPULATION FROM THE MAJOR CARDIOVASCULAR-RENAL DISEASES BY AGE AND SEX, UNITED STATES, 1920-1947 (REPRODUCED FROM *Public Health Reports*, MARCH 23, 1951, PAGE 361)

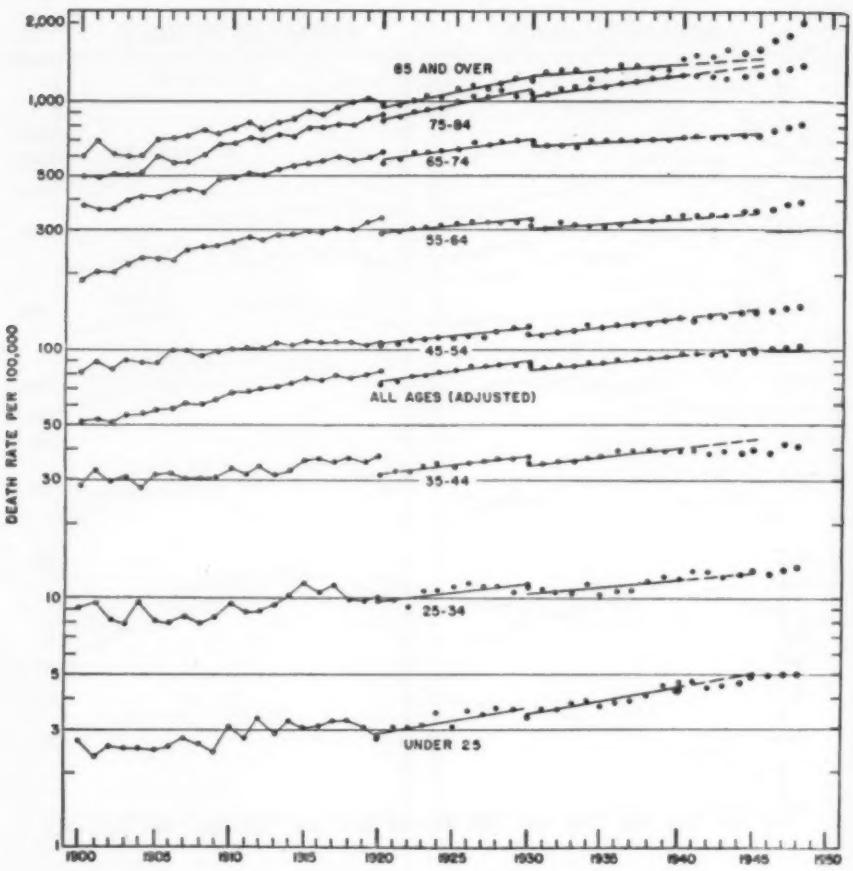

FIG. 10. NUMBER OF DEATHS PER 100,000 MALE POPULATION FROM CANCER BY AGE, UNITED STATES, 1900-1948 (EXCLUSIVE OF HODGKIN'S DISEASE AND LEUKEMIA)

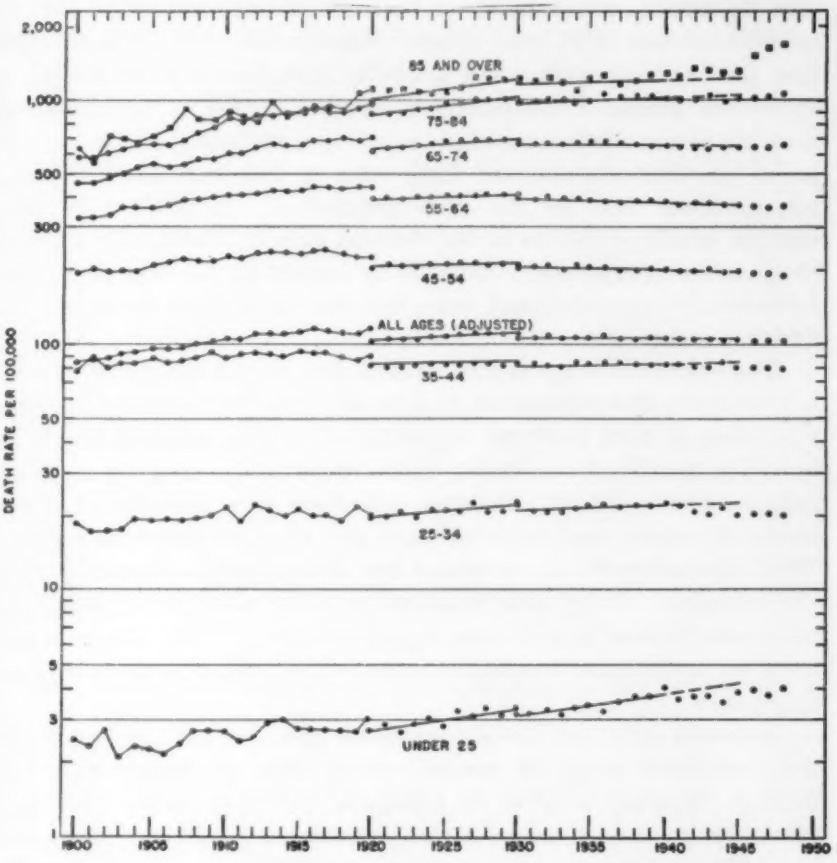

FIG. 11. NUMBER OF DEATHS PER 100,000 FEMALE POPULATION FROM CANCER BY AGE, UNITED STATES, 1900-1948 (EXCLUSIVE OF HODGKIN'S DISEASE AND LEUKEMIA)

seem unbelievably low. Not only are the rates considerably less than those for the white population at corresponding ages but there also has been a marked decrease during recent years which, if projected 20 years into the future, would result in an incredible expectation of life for nonwhite persons at 75 years of age. Examination of the data indicated that the basic population and mortality statistics must be subject to appreciable errors. Consequently, no further decline in mortality rates from all causes for the nonwhite population was assumed for any age group for which the observed death rates in 1948 were lower than the corresponding rates for the white population. In addition to these changes, erratic variations in the observed rates of decrease for adjacent five-year age groups were eliminated by computing the rate of decrease for a broader age group and using this rate for each of the component five-year groups.

The observed average annual rates of decrease for the period 1936-38 to 1946-1948, after adjustment for apparent inconsistencies and the probable effect of more universal utilization of existing medical knowledge as well as possible future developments, were used to compute mortality rates for 1960 and 1970. Separate projections were made for all causes, accidents, cancer, cardiovascular-renal, and all other causes as a group. Thus two independently computed sets of age specific mortality rates were obtained. These were compared and the assumptions underlying them were reviewed so as to eliminate inconsistent results. Major weight was given to the rates for all causes obtained by projecting the four major components.

A second set of age specific mortality rates for 1960 and 1970 was then computed using the revised annual rates of change shown in Table 4. Selected values of the expectation of life at various ages from life tables based on these rates with corresponding values from various life tables for recent years are shown in Table 5. Annual mortality rates for 1960 and 1970 are given in Table 6.

The increase in expectation of life at birth for each of the four sex-color groups is less than the increase during the past two decades. For white males the projected values are slightly less than Whelpton's low mortality estimate for native white males; however, the estimates for white females shown here for 1960 are slightly higher than Whelpton's low mortality estimate for native white females in 2000. As was pointed out above though, Whelpton's low mortality estimate for 1960 was practically equalled by the life table for white females in 1948.

TABLE 4

Annual rates of decrease (per cent) assumed in projecting mortality rates from 1947 to 1970, United States

AGE	WHITE		NONWHITE	
	Male	Female	Male	Female
0-4	4.0	4.3	4.9	4.7
5-9	3.8	5.0	3.8	5.4
10-14	3.0	5.3	4.0	5.0
15-19	1.5	3.6	4.2	4.6
20-24	1.3	4.3	4.2	4.8
25-29	1.9	4.9	4.3	4.7
30-34	2.7	4.4	4.3	4.0
35-39	2.6	3.4	4.0	3.8
40-44	2.0	3.2	3.8	3.2
45-49	1.8	2.6	3.1	2.5
50-54	1.1	2.4	1.0	2.1
55-59	1.0	2.4	1.0	1.6
60-64	0.7	2.2	1.0	1.2
65-69	0.6	2.0	1.0	1.1
70-74	0.6	1.6	0.5	1.1
75-79	0.6	1.2	0.0	0.0
80-84	0.6	0.9	0.0	0.0
85 & over	0.0	0.0	0.0	0.0

TABLE 5

Estimated values of the expectation of life at selected ages for 1960 and 1970 with corresponding values from life tables for recent years, by color and sex, United States*

YEAR	AGE					AGE				
	0	20	40	60	80	0	20	40	60	80
	White male					*White female*				
1929-31	59.1	46.0	29.3	14.7	5.3	62.7	48.5	31.5	16.1	5.6
1939-41	62.8	47.8	30.0	15.1	5.4	67.3	51.4	33.3	17.0	5.9
1948	65.5	49.0	30.7	15.4	5.4	71.0	53.8	35.0	18.1	5.8
1960	67.9	50.5	31.9	16.0	5.7	74.2	56.1	36.9	19.3	6.1
1970	69.8	51.6	32.8	16.5	5.8	76.4	57.7	38.2	20.2	6.3
	Nonwhite male					*Nonwhite female*				
1929-31	47.6	36.0	23.4	13.2	5.4	49.5	37.2	24.3	14.2	6.9
1939-41	52.3	39.7	25.2	14.4	6.6	55.5	42.1	27.3	16.1	8.0
1948	58.1	42.9	26.8	15.2	9.2	62.5	46.8	30.3	17.8	11.9
1960	63.6	46.8	29.3	16.4	9.3	67.9	50.7	33.0	19.2	12.0
1970	66.9	49.0	30.8	16.9	9.3	71.4	53.2	34.8	20.0	12.0

* Data for 1929-31, 1939-41 and 1948 are from tables computed by the National Office of Vital Statistics.

The projected decline in death rates for nonwhite males is slightly greater than that assumed by Whelpton in making his low mortality projection. But just as for white females, a more rapid rate of decline in death rates for nonwhite females is assumed here than Whelpton used for his low estimate, the values of the expectation of life at various ages

TABLE 6

Estimated annual mortality rates per 1,000 population for the United States in 1960 and 1970 by age, sex, and color

AGE	1960				1970			
	WHITE MALE	WHITE FEMALE	NON-WHITE MALE	NON-WHITE FEMALE	WHITE MALE	WHITE FEMALE	NON-WHITE MALE	NON-WHITE FEMALE
0-4	5.8	4.3	7.9	6.6	3.9	2.8	4.8	4.1
5-9	0.5	0.3	0.6	0.4	0.3	0.2	0.4	0.2
10-14	0.6	0.3	0.7	0.5	0.4	0.1	0.5	0.3
15-19	1.2	0.5	1.4	1.3	1.0	0.3	1.0	0.8
20-24	1.6	0.6	2.4	2.0	1.4	0.4	1.6	1.2
25-29	1.5	0.7	2.9	2.3	1.2	0.4	1.9	1.4
30-34	1.7	0.9	3.5	3.0	1.3	0.6	2.3	2.0
35-39	2.4	1.5	5.2	4.6	1.8	1.1	3.5	3.2
40-44	4.0	2.1	7.2	6.4	3.3	1.6	4.9	4.6
45-49	6.5	3.5	11.4	10.0	5.4	2.7	8.4	7.8
50-54	11.3	5.4	22.7	15.0	10.2	4.2	20.5	12.1
55-59	16.8	8.0	27.8	20.0	15.2	6.3	25.2	17.0
60-64	26.1	13.0	34.0	29.6	24.3	10.4	30.8	26.3
65-69	39.9	22.2	46.1	40.0	37.6	18.2	41.7	35.8
70-74	57.9	37.5	61.9	46.0	54.5	32.1	58.9	41.3
75-79	86.9	63.1	78.4	58.1	81.8	55.8	78.4	58.1
80-84	128.2	108.4	88.0	67.0	120.8	99.3	88.0	67.0

in 1970 being roughly comparable to those obtained from Whelpton's low mortality projections for 1990.

EFFECT OF PROJECTED MORTALITY RATES UPON POPULATION CHANGE

Mortality rates for the white population in the United States now are so low that their trend, relative to that of the birth rate, is not a major factor in determining changes in the future rate of growth of the total population. However, if the birth rate fails to continue at its

present level but falls to that prevailing around 1940, the future trend in mortality will become a major factor in determining whether or not the total population will continue to increase slowly, become stationary, or decrease. For the nonwhite population, the potential effects of increased longevity upon changes in the rate of population growth are greater than for the white population.

Ninety per cent of a cohort of white females subject to the mortality rates of 1948 would live until age 50, which for practical purposes may be considered to be the end of the childbearing period; according to

TABLE 7

Age distribution of a stationary population subject to the observed mortality rates of white females during 1948 and the assumed mortality rates for 1970. (100 births annually)

AGE	1948			1970		
	NUMBER	PER CENT OF TOTAL	PER CENT OF POSSIBLE MAXIMUM POPULATION	NUMBER	PER CENT OF TOTAL	PER CENT OF POSSIBLE MAXIMUM POPULATION
0-19	1934	27	97	1974	26	99
20-39	1900	27	95	1956	25	98
40-59	1784	25	89	1890	25	95
60-79	1271	18	64	1506	20	70
80-99	214	3	11	318	4	16
Total	7103	100	–	7644	100	–

the present projections the corresponding percentage for 1970 would be 95. In other words, the gross and net reproduction rates would be so nearly equal that mortality would not be an important factor in determining effective fertility unless the gross reproduction rate were approximately unity.

Perhaps the most important effect of the trends in mortality assumed here would be upon the age distribution of the population provided immigration is negligible and fertility is not far from the bare replacement level. A cohort subject to the assumed mortality rates for white females in 1970 would have an almost rectangular age distribution from birth until age 80 (Table 7). After that age, deaths would occur very

rapidly so that almost the entire cohort would be dead by age 100. The stationary population resulting from the 1970 mortality rates would be 7.6 per cent greater than that resulting from the 1948 rates. For nonwhite males, the corresponding increase would be 15.3 per cent, showing that the trend in mortality still is an important factor in the growth of nonwhite population.

Some indication of the effect of errors in forecasting mortality rates upon population projections can be obtained from Table 7. The maximum number of persons in any twenty-year age group of a stationary population resulting from 100 births annually would be 2000. This maximum could be reached only if no person died. Table 7 shows the size of the stationary population which would arise from 100 births annually if subject to the observed mortality rates of white females during 1948 and the projected mortality rates for 1970. For example, 100 white female births per year if subject to the observed mortality rates of 1948 would generate a stationary population of 1,784 at ages 40-59. This number would be 25 per cent of the total population of all ages and 89 per cent of the possible maximum population for that age group of 2,000. Consequently, a population forecast assuming no improvement in mortality after 1948 could not be more than 11 per cent in error, due to the effect of mortality alone, for the age group 40-59, barring an increase in the death rate at that age. The maximum error would be 3 per cent for the age group 0-19, 5 per cent for the age group 20-39, and 36 per cent for the age group 60-79. The figure of 89 per cent for the age group, 80-99, is not very realistic since we can hardly expect that any appreciable number of persons will live to age 100.

If the assumed improvement in longevity takes place, the age distribution of the stationary population would be almost rectangular up to 80 years of age. Furthermore, the stationary population in the age group 40-59 would be only 5 per cent less than the possible maximum population for that age group. It is apparent from the data in Table 7 that errors in mortality projections would have only a negligible effect upon population forecasts except for ages above 60. For the other major classes of the population, especially nonwhite males, the possible effects of errors in projecting mortality rates upon population forecasts would be greater than those shown in Table 7 for white females. For the nonwhite males, the projected 1970 mortality rates in combination with 100 annual births would result in a stationary population which would be 93 per cent of the possible maximum population at ages under 20,

88 per cent at ages 20-39, 69 per cent at ages 40-59 and 33 per cent at ages 60-79. The corresponding figures for white males and nonwhite females fall between those for nonwhite males and white females.

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ENVIRONMENTAL GROWTH FACTORS AND SELECTIVE MIGRATION *

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INTRODUCTION

THE PRESENT study shows that a group of emigrants from a Mexican town differ physically from the individuals who were left behind, but only in the case of those migrants who were not fully grown when they left home. The fact that the younger migrants who stayed longer in the United States show the bigger difference suggests as an explanation some factor, probably dietary, in the environment during the growing period. Those who migrated after they were fully grown do not differ significantly from those who never left. Selection therefore seems to be ruled out as a major factor.

Although several previous studies (Boas, 1911; Shapiro, 1939; Goldstein, 1943; and Lasker, 1946) have shown that American-born individuals of foreign descent usually exceed immigrants in stature and some other measurements—apparently because of environmental influences—it has usually been assumed that such differences as exist between immigrants and sedentes (as the individuals who stayed at home were

* The study in Paracho, Michoacán, of sedentes and returned migrants who had spent various periods of time in the United States was conducted during the period from May to September, 1948. The work was generously supported by a grant from the Wenner-Gren Foundation for Anthropological Research to the author and Dr. F. Gaynor Evans. Dr. Evans shared in the planning and carried on a parallel project. The author's companions in the field, Professor Pablo Velasquez G. and Miss Bernice Kaplan, by their friendliness, skill and diligence made possible the collection of the data. Aid by numerous Mexican officials and citizens including Dr. F. Rubín de la Borbolla, director of the Museo Nacional de Arte Popular, Licenciado Antonio Arriaga, director of the Museo Michoacano, Sra. Beatriz del Castillo, and especially the late Sr. Cesario Sosa and the other residents of Paracho is gratefully acknowledged. Dr. W. W. Howells and Mr. Bruno Lasker kindly read and criticised earlier drafts of this paper.

designated by Shapiro) may result from selective migration. Goldstein (1943) attempted to check this very point in a study of Mexicans in their own country and in the United States. He showed that size differences between immigrants and sedentes do occur, with the former usually being larger. He says: "This fact would seem to point to physical selection among the Mexican emigrants, to some degree at any rate. Yet it must be recalled," he adds, "that . . . some of the observed differences might, in some measure, be due to adaptation to the new environment (e. g., weight, size of hand)." Although the comparison between migrants and those born in the United States involved close relatives (parents and their own adult children), the comparison of immigrants and sedentes allowed of no such close genetic control. In fact, in discussing the greater breadth of the face in the migrant Mexicans, Goldstein suggests the possibility that there might be a greater proportion of American Indian admixture in the migrants than in the sedentes. However, he concludes: "In any event, it seems to me the evidence pertaining to physical selection in Mexican migrants is not conclusive, and until further and more exhaustive material is available the question must needs remain in abeyance."

The present investigation represents an attempt to assess the relative importance of physical selection of emigrants and of environmental growth factors in a situation in which returned emigrants, who had been in the United States for various periods of time and at different ages, could be compared with sedentes of the same genetic background.

MATERIAL

Geography. For such a study it was necessary to choose a community where numerous returned migrants live and where climatic, dietary and health factors in the environment contrast with those experienced by immigrants in the United States. Gamio (1930) and Goldstein (1943) describe two such areas in Mexico: first, the states which border on Texas, New Mexico, Arizona and California; and second, the west central Mexican states of Jalisco, Guanajuato and Michoacán.

The latter area was selected. It was assumed that there might be more contrast in environment for the migrants who had traveled several hundred miles to the United States. The town of Paracho, Michoacán was selected because of its high proportion of emigrants and its location in a region (the Tarascan area) where living conditions have been pre-

viously studied (Beals, 1946; Foster, 1948; West, 1948; and Brand, 1951).

According to the census of 1940, the population of Paracho consists of 3,304 individuals. The town is in the heart of the Sierra Tarascan region at an elevation which, according to various authorities, is somewhere between 5,142 feet (census of 1940) and nearly 8,000 feet (West, 1948, Map 1) above sea level. The climate is temperate with dry cool winters and wet, but not hot, summers. The soil has been enriched by dust from the Parícutin volcano. Fertilizers are used only in gardens within the town.

Health and Diet. The health of the people is difficult to evaluate. A physician who had practiced in the town for a year and one-half informed us that the chief diseases are dysenteries, both amoebic and bacillary. Typhoid fever is also common. Of the infectious diseases smallpox is now rare because of periodic campaigns to have the children vaccinated. Malaria, although not uncommon, is said always to have been acquired during trips to the hot lands. During the time we worked in the village there was an epidemic of whooping cough and there were about a dozen deaths of small infants from this cause. Infant mortality in general is high.

As for diet, the staple foods are similar to those of other parts of Mexico: tortillas, other maize products, and beans. Meat, fish, dairy products, vegetables, fruits, and cereal foods are all used, and one gets the impression of a diet of good quality, ordinarily adequate in quantity. Extreme poverty is, no doubt, the chief cause of such inadequacies as exist and, although rare, does occur. Few individuals are obese and, although evidence of frank dietary deficiency was not obtained, a lean appearance is common. Diarrhea and alcoholism are possible factors in poor nutrition of some individuals. Numerous cases of goiter were seen.

Migration. Older people in the community agree that the first man to leave Paracho for the United States left in about 1904 and soon returned to the town with accounts of his experiences. From that time on, the flow of temporary and permanent migration has been considerable. Of 185 male migrants measured, 58 had first gone before 1916, 51 went during the following 12 years, but only 3 individuals first went during the 12 years of depression which followed. During the years following 1940, 73 men went for the first time, all but a very few under contract as temporary laborers. Of those who stayed in the United States for only one year (here and hereafter used to include from 3 to 18 months)

81% first migrated after 1940, while of those who went to the United States for a longer period of time less than 12% first went after 1940. In fact, among those who went before the age of 17 and who stayed 2 years or more, all had first gone before 1924.

There has always been a considerable flow of migrants back to Paracho and many individuals have been to the United States more than once. In recent years immigration into the United States has been more difficult. Nevertheless, through renewal or violation of contracts or other means, some individuals have maintained a certain degree of freedom to come and go.

Experiences in the United States. Most of the men from Paracho went originally to the Southwestern and Central States where they worked on the railroads. Later they increasingly went to the industrial cities of the Midwest to work in steel mills and other heavy industries. Some individuals have worked in agriculture and this has been the most common occupation since 1943.

Ordinarily the migrants lived with other Mexicans. When asked whether they ate Mexican, American or a mixed style of food while in the United States, three-quarters of the men said American-style. Usually they apparently meant by this that they ate potatoes.

The migrants were asked in what states they had lived in the United States. From among 174 male migrants, 431 answers were recorded. In general they had lived in California or the Midwest, with sizable numbers also in the Southwest. Only a very few had been in the Eastern Seaboard States.

Selection of Material. Measurements on 477 individuals are included in the analyses. This sample represents approximately 30% of the adult population from which it was drawn. The purpose was to get samples of individuals over 18 years old with various migrational histories but unselected in regard to other factors which might affect the measured dimensions. A list of persons who had been in the United States for a considerable period of time was compiled. After many of these individuals, their siblings, their spouses and many of their spouses' siblings had been measured, other lists of male sedentes and their relatives were added. Most of the persons on the various lists were measured. Those measured are nearly random samples of the categories they are taken to represent in respect to part of the town in which they reside, racial antecedents, and, it is therefore believed, physique. They are not an

entirely random group in respect to occupation or family membership, but these factors are so distributed in the various subgroups that they should not bias the comparisons. Likewise, a few individuals have been included who are not strictly members of the community and the breeding population, but they are also proportionately distributed throughout the different subgroups.

All but 2 or 3 of the women in the town who had ever been in the United States were measured. The female sedentes are for the most part wives and sisters of men in every category and were selected at random. There is, therefore, little likelihood of any sample bias in either female series.

In the case of the males, a higher proportion of certain occupational groups were included. For instance, woodworkers and others engaged in home industry were more available for study than were farmers or traveling men. It is hard to see how this could bias the comparisons which are the subject of this study, however, for there are virtually no differences in the proportion of sedentes and return migrants in the various occupations.

Some of the individuals measured were relatively recent immigrants from other towns of the region. Among those measured, the proportion of individuals both of whose parents were born in other communities is 13% for female sedentes, 17% for female migrants, 15% for male sedentes and 13% for male migrants. For each of these 4 series, the proportion of individuals with either parent born outside Paracho falls within the 30-35% range. Although the localities whence these elements were introduced are diverse, most of them are in the immediate vicinity of Paracho and the people must represent the same stocks as are present in the old families of the town. Certainly no disproportionate contribution of any ethnic element was made to any of the subgroups studied.

One evidence of the randomness of the sample is to be seen in the distribution of the individuals within the town. The map (Fig. 1) shows that the number of individuals measured in any part of the town varies proportionately with the number of houses in the block. However, the method of collection would tend to sample several members of one family or of one household.

In considering the sedentes it should be kept in mind that some of them may still go to the United States at some future time. This possibility is emphasized by the relatively large number of young men in this group. Such individuals are now pre-migrants rather than non-migrants.

The migrants, for their part, constitute a sample of those who had gone to the United States at some time and had subsequently returned to Paracho. The total number of individuals from Paracho living in the United States in 1948 was probably under 100. Even if one were to add a similar number of returned migrants who are living in other parts of Mexico, it seems unlikely that a large enough fraction of the total

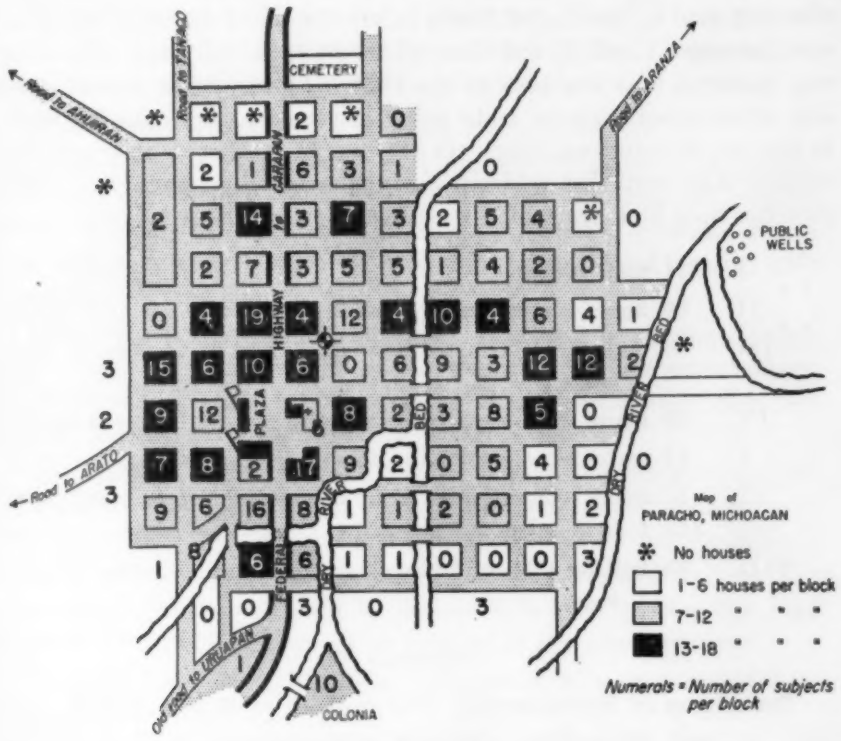

FIG. 1. MAP OF PARACHO, MICHOACÁN.

migrant population would be unsampled seriously to discredit use of the sample to represent the emigrant population.

Seriation. In sorting the material into subgroups, it was necessary to set up the classification in such a way that each subgroup would be distinguished from others by criteria which are meaningful for the hypotheses, and that there should be enough individuals in each subgroup to warrant statistical comparisons. In line with these conditions,

the measured individuals were first divided by sex and then by whether they had ever been to the United States or not. The male migrant series was divided into those who had gone for one year (75 individuals) and those who had spent a longer period of time in the United States (111 individuals). As normal growth of bone is limited after the closure of epiphyses (which takes place by the mid twenties) and is most rapid during adolescence, the series were further divided into those who first went to the United States before the age of 17, those who first went between 17 and 27, and those who went at an older age. One man was measured who was born in the United States; he is probably the only adult American-born male living in Paracho, and data pertinent to him are therefore excluded. In the case of the female migrants the number is so small that subdivision of the series is not warranted. The subseries have been designated with Roman numerals as follows:

I. 111 male sedentes.
II. 30 males who migrated before age 17 for two or more years.
III. 66 males who migrated between 17 and 27 for two or more years.
IV. 30 males who migrated between 15 and 27 for one year.
V. 44 males who migrated at 27 or over for one year.
VI. 15 males who migrated at 27 or over for two or more years.
VII. 157 female sedentes.
VIII. 23 females who migrated at various ages for two or more years.

METHODS

Techniques of Measurement. The methods of Martin (1928) were used for most dimensions. Subjects were measured in their clothes except for shoes and jackets. All measurements were taken directly on the subject and not by subtraction. Unilateral measurements were taken on the left side except for head height which was taken on both sides and is given as the average. Tibia length was measured with the subject seated and with his left foot placed on the right knee; in this position the landmarks for measurement (medial tibial condyle and medial malleous) are readily palpated and a more reliable measurement than the conventional one is possible. Nose breadth and mouth breadth were measured only when the subject's face was composed.

Reliability of Technique. The anthropometrist's assistant was measured at intervals during the field work. For all measurements the coefficient of variability on a single individual is a fraction of that for the corresponding measurement on any of the subgroups of the series. See Table 1. In all dimensions, therefore, the inaccuracies which would be revealed by retesting measurements would be reasonably small; this is particularly true for bizygomatic diameter, stature, head breadth, bigonial diameter and tibia length. Furthermore, there is a lack of trend in the successive measurements of one individual which suggests that errors caused by technical shortcomings are random.

Definitions. Several terms are used in a specific way.

Environment is used to include all non-genetic influences on growth. It is a complex concept including geographical, nutritional and cultural factors. In the case of a contrast in which migration is involved, change in occupation and the methods of work must be considered together with changes in diet and climate.

Selection refers to average differences, in respect to physique, dependent on who migrated and not on the effects of the new environment. No distinction is made between purposeful and accidental choice, nor between personal decisions and those made by others.

No difference is used to mean that the average divergence is less than the standard error. If similar findings are typical, additional series of less than 4 times the size of the present sample would fail to establish a significant difference at the 5 per cent level of probability.

Tendency or *tend* is used to denote differences greater than the standard error but less than twice as large as the standard error.

Significant is used to describe a difference of twice or more times its standard error.

FINDINGS

The purpose of this analysis is ultimately the comparison of the various subgroups to each other. It turns out that the chief differences represent a general size factor and could be moderately well expressed by some composite measurement. This conclusion can only be reached, however, after a wide variety of measurements are separately analyzed. Long bone growth, lateral growth, fat deposition, muscularity, cartilage growth and other factors are unequally represented in the different anthropological measurements. Even for a single measurement the simultaneous examination of the rank order of 6 series and the significance

TABLE 1

Coefficient of variation

*Comparison of the ratio of standard deviation to the mean for repeated measurements on one individual with those for one measurement each on several individuals**

	ONE INDIVIDUAL	MALES						FEMALES	
		I	II	III	IV	V	VI	VII	VIII
Number	9-10	100-111	28-30	59-66	29-30	39-44	13-15	141-157	18-23
Stature	0.4	3.6	3.6	3.1	2.9	3.5	3.4	3.1	2.6
Sitting height	0.9	3.6	3.5	3.7	2.9	3.3	3.8	3.4	2.6
Biacrominal diameter	1.4	5.1	4.7	4.3	4.1	4.5	4.3	4.2	4.0
Chest width	1.9	7.1	5.5	5.5	8.6	6.4	6.8	7.2	7.0
Chest depth	—	7.9	6.6	7.0	9.3	6.8	8.0	—	—
Arm length	0.9	4.3	4.8	3.7	4.1	4.3	3.8	3.9	3.0
Radius length	2.4	5.5	4.6	4.3	5.2	5.0	3.6	4.7	4.0
Hand length	1.4	4.5	4.6	4.2	4.5	4.9	4.6	4.1	3.9
Hand breadth	1.9	4.7	4.2	4.7	4.6	4.5	2.4	4.4	4.5
Tibia length	0.7	5.9	5.3	5.0	4.8	6.2	4.6	5.2	3.1
Foot length	1.6	4.0	5.0	4.2	4.1	4.6	4.2	4.2	3.5
Head length	0.8	3.3	3.6	3.2	3.6	3.7	3.2	3.5	2.8
Head breadth	0.5	3.6	4.5	3.5	3.5	3.3	2.9	3.6	4.5
Head height	1.6	4.1	4.9	4.5	4.3	3.2	4.5	4.5	3.5
Minimum frontal diameter	1.9	4.0	5.5	3.9	3.5	4.3	3.6	3.6	4.0
Bizygomatic diameter	0.4	3.7	4.0	3.4	3.9	3.5	3.3	3.6	3.7
Bigonial diameter	0.8	5.7	5.0	5.3	6.5	4.6	5.6	4.8	4.3
Total facial height	1.5	5.4	4.8	6.2	4.6	4.1	4.7	4.8	4.4
Upper facial height	2.9	6.2	6.4	6.3	5.1	5.5	6.0	6.3	5.4
Lower facial height	3.8	7.7	6.8	7.7	8.3	7.1	6.8	7.1	10.2
Nose height	2.4	6.2	4.8	6.9	4.0	6.6	5.6	6.1	6.3
Nose breadth	1.7	7.8	9.5	8.8	6.5	6.7	7.9	8.5	7.0
Mouth breadth	3.7	8.1	6.4	6.5	5.5	5.1	6.6	7.2	5.2
Interocular width	3.7	8.4	8.7	7.9	7.9	7.7	7.1	8.5	10.2
Ear breadth	4.7	7.6	9.1	8.6	8.5	8.5	8.6	9.0	6.9
Ear height	3.3	7.3	7.4	6.2	6.3	6.6	6.6	6.7	4.9

* For description of subseries I-VIII see key to diagrams, p. 272.

of 15 comparisons can best be achieved graphically. This is undertaken in Figures 2-28. The analysis of similarities and differences in the general form of these diagrams permits a further generalization. It is precisely the diagrams of those dimensions which most highly correlate with stature, and which best represent general size, which show the dominant pattern.

Consider stature, Figure 3. The size of the black dots indicates, for each sex, the rank order of the mean dimension. Thus for females the migrants (VIII) are on the average taller than the sedentes (VII). For the males, the order of the means from tallest to shortest is: first, migrants who first left before the age of 17 and who stayed in the United States for 2 or more years (II); second, migrants who first went to the United States at the age of 17 to 27 and who stayed 2 or more years (III); third, migrants who first left between the age of 15 and 27 but who stayed only one year (IV); fourth, the sedentes (I); fifth, the migrants who left for a single year after the age of 27 (V); and sixth, those who went to the United States after the age of 27 and who spent 2 or more years there (VI). To evaluate these differences between subseries, a pattern of solid black wedges (indicating significant difference), hollow wedges (signifying tendencies), and dotted lines (indicating lack of appreciable difference) has been added to the charts. In Figure 3 it will be seen from the solid black wedge and its direction, that the amount by which female migrants (VIII) exceed female sedentes (VII) in stature is statistically significant. Likewise, the symbol for male migrants who first went to the United States between the ages of 17 and 27 and who stayed 2 years or more (III) is connected by a solid wedge pointing to the symbol for male sedentes (I); hence the former are taller than the latter by a statistically significant amount. In Figure 3, hollow wedges point from subseries II and IV to I, V, and VI, indicating that the mean statures of II and IV each exceed those of I, V, and VI by one to 2 times the standard error of the difference. Likewise the mean stature of III tends to exceed that of V and VI. Finally, it will be seen that I, V, and VI are connected by dotted lines and that II, III, and IV are similarly connected. This indicates that the differences in mean stature between subseries I, V, and VI are in each instance less than the standard error, and likewise for the differences between subseries II, III, and IV.

* For description of subseries I-VIII see key to diagrams, p. 272.

KEY TO DIAGRAMS (Figs. 2-28)

SUBSERIES		AGE AT WHICH SUBJECTS FIRST MIGRATED TO U. S.	TOTAL DURATION OF STAY IN THE U. S.
Male	I	Never	0
	II	Before 17	2 or more years
	III	17–27	2 or more years
	IV	15–27	1 year
	V	27 or over	1 year
	VI	27 or over	2 or more years
Female	VII	Never	0
	VIII	Various	2 or more years

Fig. 2 Age when measured

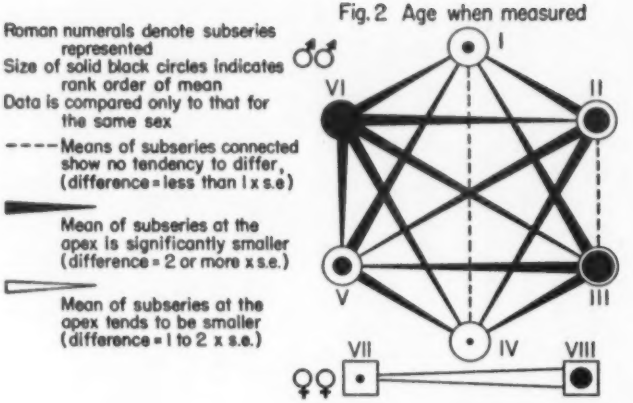
Roman numerals denote subseries represented
Size of solid black circles indicates rank order of mean
Data is compared only to that for the same sex
Means of subseries connected show no tendency to differ, (difference = less than 1 x s.e)
Mean of subseries at the apex is significantly smaller (difference = 2 or more x s.e.)
Mean of subseries at the apex tends to be smaller (difference = 1 to 2 x s.e.)
I
II
III
IV
V
VI
VII
VIII

Fig. 3 Stature

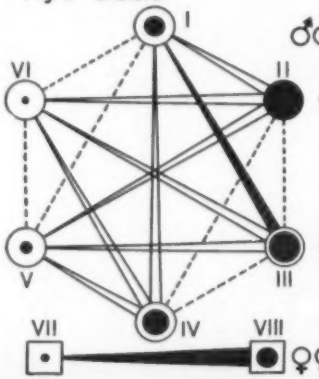

Fig. 4 Sitting height

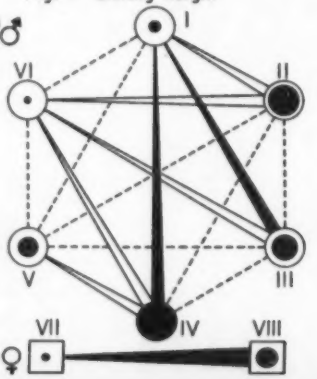

Fig. 5 Biacromial diameter

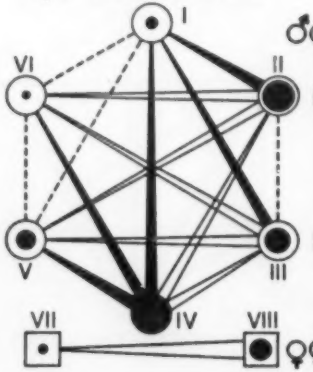

Fig. 6 Chest width

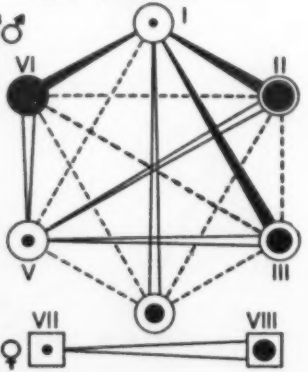

Fig. 7 Chest depth

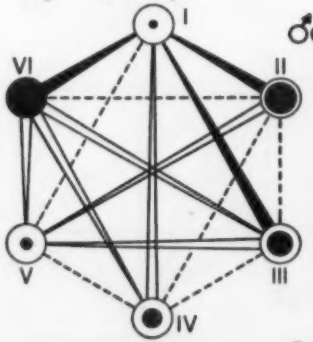

Fig. 8 Arm length

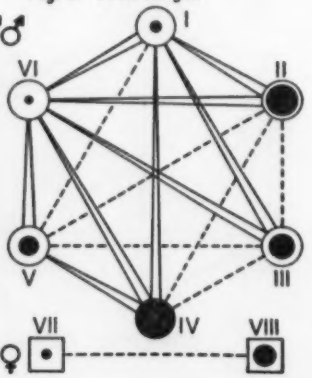

Fig. 9 Radius length

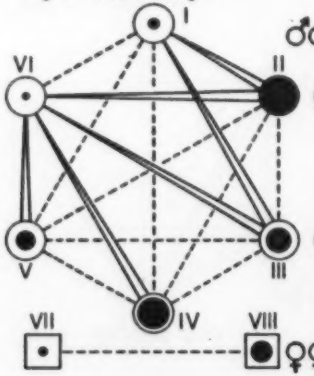

Fig. 10 Hand length

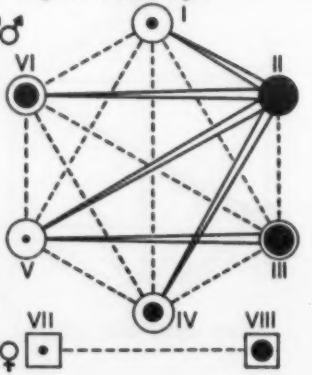

Fig. 11 Hand breadth

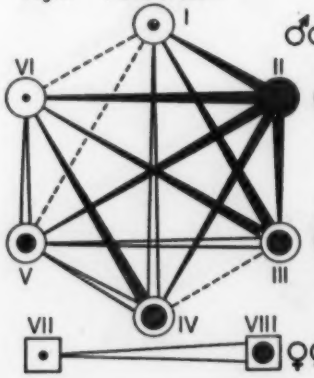

Fig. 12 Tibia length

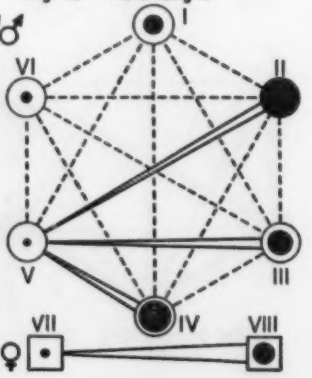

Fig. 13 Foot length

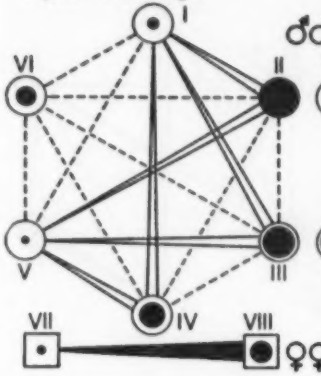

Fig. 14 Head length

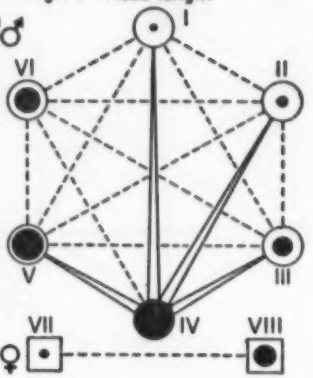

Fig. 15 Head breadth

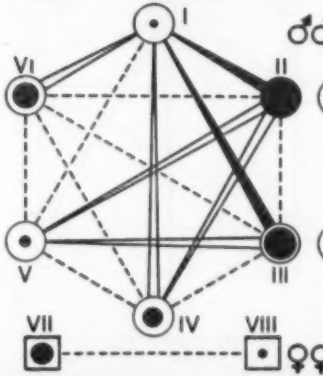

Fig. 16 Head height

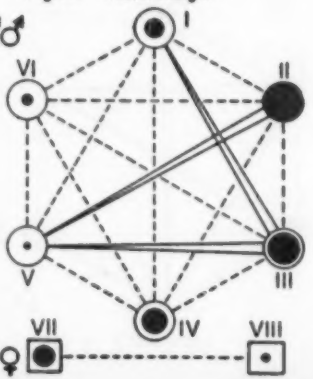

Fig. 17 Min. front. diam.

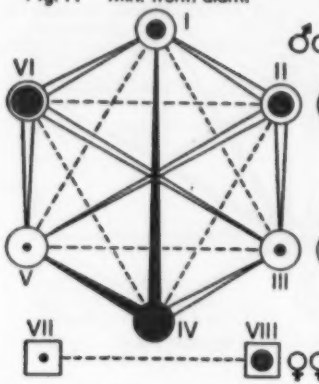

Fig. 18 Bizygomatic diam.

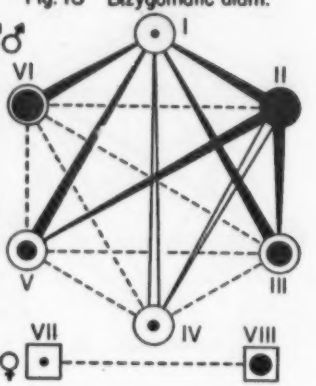

Fig. 19 Bigonial diam.

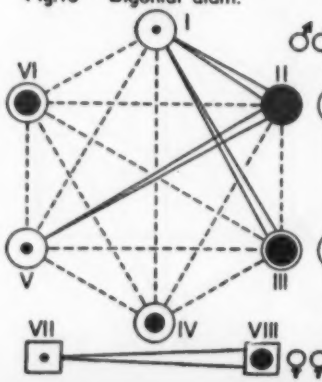

Fig. 20 Total facial height

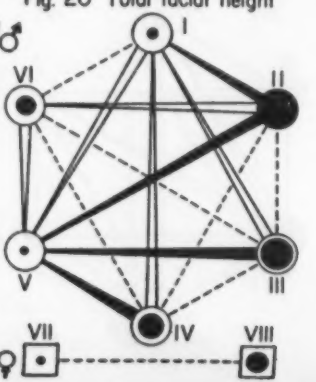

Fig. 21 Upper facial height

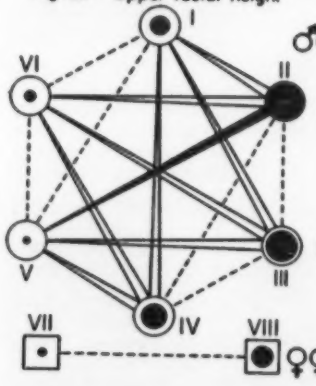

Fig. 22 Infradental height

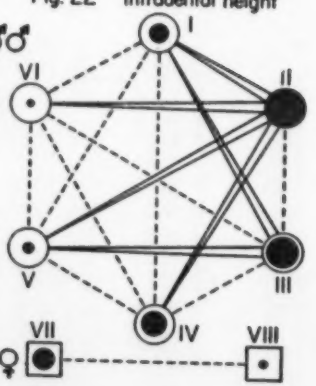

Fig. 23 Nose height

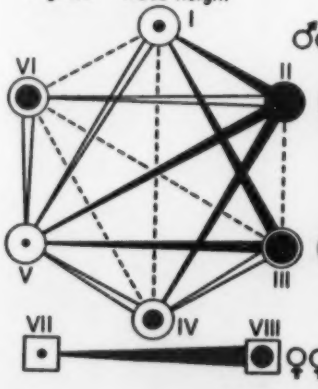

Fig. 24 Nose breadth

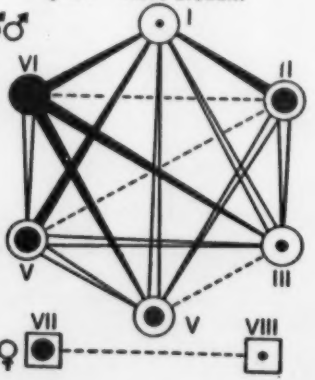

Fig. 25 Mouth width

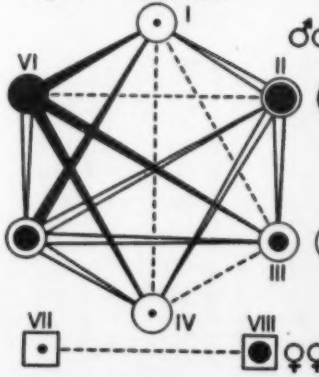

Fig. 26 Interocular width

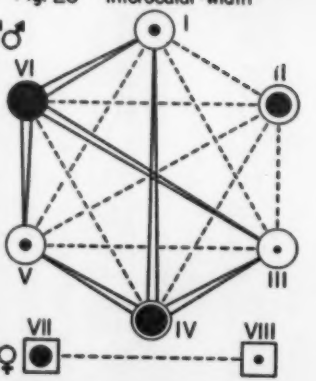

Fig. 27 Ear breadth

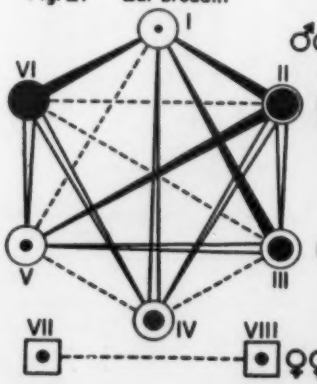

Fig. 28 Ear height

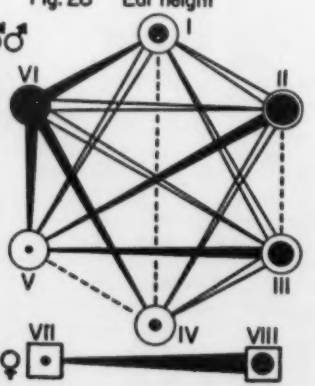

TABLE 2

Mean dimensions (mm.)

	MALES						FEMALES	
	Sedentes	Migrants					Sedentes	Migrants
	I	II	III	IV	V	VI	VII	VIII
Number	100-111	28-30	59-66	29-30	39-44	13-15	141-157	18-23
Age (years)	35.8	47.4	47.8	34.6	41.4	61.4	38.9	42.2
Stature	1618.0	1642.7	1635.6	1633.1	1615.1	1610.2	1512.3	1532.9
Sitting height	850.4	861.5	860.8	863.1	855.2	849.7	802.4	819.1
Biacromial diameter	379.9	389.6	387.8	394.1	382.7	379.3	354.8	359.1
Chest width	275.0	284.4	282.7	281.6	277.0	286.5	271.7	276.2
Chest depth	221.9	228.8	228.2	226.8	223.7	233.9	—	—
Arm length	734.6	742.4	740.8	744.4	736.4	726.1	679.2	682.5
Radius length	247.6	252.0	249.7	249.8	249.2	245.5	229.1	230.5
Hand length	180.3	183.3	181.5	180.4	179.9	180.5	166.7	168.1
Hand breadth	80.0	83.2	81.4	81.4	80.4	79.5	71.7	72.7
Tibia length	369.9	372.8	371.6	372.1	366.2	367.3	341.9	345.1
Foot length	248.3	252.4	251.0	250.7	248.0	249.7	227.8	232.1
Head length	187.7	187.9	188.4	190.4	188.7	188.5	181.2	182.2
Head breadth	145.9	148.7	147.5	147.0	146.5	147.4	142.0	141.7
Head height	127.5	128.7	128.6	128.0	127.2	127.4	123.5	122.6
Minimum frontal diameter	103.8	105.0	103.7	105.4	103.4	105.1	102.2	102.4
Bizygomatic diameter	135.2	139.9	137.5	137.3	137.4	138.6	130.0	130.9
Bigonial diameter	103.7	106.0	105.3	104.5	104.4	105.1	99.0	100.0
Total facial height	123.0	126.1	125.0	124.9	121.5	123.3	117.0	117.8
Upper facial height	73.7	75.5	75.0	74.9	73.3	73.5	70.7	71.1
Lower facial height	43.6	44.8	44.4	43.8	43.4	42.9	41.8	41.6
Nose height	54.9	56.8	56.3	55.4	54.3	55.5	51.5	53.0
Nose breadth	40.3	41.9	40.8	40.9	41.9	42.9	37.2	36.9
Mouth breadth	56.1	57.5	56.6	56.1	57.4	59.1	52.9	53.4
Interocular width	32.7	33.0	32.6	33.5	32.7	33.7	32.2	32.1
Ear breadth	35.3	37.2	36.4	36.0	35.5	37.3	33.8	33.8
Ear height	67.0	68.2	68.1	66.5	66.0	70.5	62.6	64.7

A series of charts similar to Figures 2 to 28 could be used to compare the differences in standard deviation between the various subgroups. In that case the solid black wedges would represent significant F scores: F is the quotient of the square of the larger standard deviation divided by the square of the smaller. This detailed analysis is not presented here because the heterogeneity of variability is only slightly greater than would be expected by chance. Of 415 comparisons, 19 (4.6%) are statistically significant at the two percent level of probability. A greater than chance number of significantly higher variances is shown by the sedentes and by each of the two groups of migrants who left before the age of 27 and who stayed in the United States two or more years (series I, II and III). The two series of migrants who had migrated after the age of 27 and the one group who went when younger but only for a year (series V, VI and IV) show a greater than chance number of significantly lower variances. The high standard deviation of sedentes in respect to age may in part account for the tendency of this group to be more variable in some dimensions.

Because of the somewhat different average ages of the various subgroups, consideration of the age factor may be important in respect to the means also, and the mean dimensions for sedentes of various ages have been calculated (Lasker, 1953). The mean differences between the various other subgroups and sedentes have been corrected for age on this basis (Table 4). In these corrected data each migrant is compared, in respect to each dimension, with the average for all sedentes in his age group. The differences shown in Table 4 are therefore age-weighted.

Status of the Various Subgroups. In assessing the role of environmental factors and selective factors in the adult physique, a summary statement concerning the various subgroups measured will help to emphasize the principal contrasts.

I. *Male sedentes.* The non-migrant men tend to be smaller than the total migrant series. Some inclination in this direction is noticed for all 26 measured dimensions and in 12 of them the difference is significant. The smaller size of the sedentes is particularly noticeable in respect to certain breadth dimensions such as bizygomatic diameter, biacromial diameter, and chest width, but it is also reflected to some extent in the size of every measured part of the head, face, limbs and trunk.

TABLE 3

Standard deviations (mm.)

	MALES						FEMALES	
	Sedentes	Migrants					Sedentes	Migrants
	I	II	III	IV	V	VI	VII	VIII
Number	100-111	28-30	59-66	29-30	39-44	13-15	141-157	18-23
Age (years)	16.4	6.3	11.7	12.6	12.4	16.7	14.2	12.5
Stature	58.3	59.0	51.3	48.1	57.2	54.5	47.3	40.0
Sitting height	30.7	29.9	32.0	25.2	28.4	32.3	27.3	20.9
Biacromial diameter	19.2	18.4	16.8	16.2	17.2	16.2	14.9	14.4
Chest width	19.6	15.7	15.6	24.4	17.7	19.4	19.6	19.3
Chest depth	17.6	15.1	16.0	21.1	15.2	18.7	—	—
Arm length	31.4	36.0	27.5	30.4	31.4	27.7	26.5	20.5
Radius length	13.7	11.6	10.8	12.9	12.4	8.9	10.7	9.3
Hand length	8.1	8.4	7.7	8.1	8.8	8.3	6.8	6.6
Hand breadth	3.7	3.5	3.8	3.7	3.6	1.9	3.2	3.2
Tibia length	21.7	19.7	18.7	18.0	22.7	17.0	17.8	10.7
Foot length	10.0	12.7	10.7	10.4	11.5	10.4	9.6	8.1
Head length	6.1	6.9	6.1	6.9	7.1	5.9	6.3	5.2
Head breadth	5.2	6.6	5.1	5.1	4.8	4.3	5.1	6.4
Head height	5.2	6.3	5.8	5.5	4.1	5.8	5.5	4.3
Minimum frontal diameter	4.1	5.7	4.0	3.7	4.4	3.8	3.7	4.1
Bizygomatic diameter	5.0	5.6	4.6	5.4	4.8	4.5	4.6	4.8
Bigonial diameter	5.9	5.3	5.6	6.8	4.8	5.9	4.8	4.3
Total facial height	6.6	6.1	7.8	5.7	5.0	5.8	5.6	5.2
Upper facial height	4.6	4.8	4.7	3.8	4.1	4.4	4.4	3.8
Lower facial height	3.3	3.1	3.4	3.6	3.1	2.9	3.0	4.2
Nose height	3.4	2.7	3.9	2.2	3.6	3.1	3.1	3.3
Nose breadth	3.2	4.0	3.6	2.6	2.8	3.4	3.2	2.6
Mouth width	4.5	3.7	3.7	3.1	2.9	3.9	3.8	2.8
Interocular width	2.7	2.9	2.6	2.7	2.5	2.4	2.7	3.3
Ear breadth	2.7	3.4	3.1	3.1	3.0	3.2	3.0	2.3
Ear height	4.9	5.0	4.2	4.2	4.4	4.7	4.2	3.2

Ear breadth	2.1	0.1	0.3	0.1	0.2	0.2	0.1	0.1
Ear height	4.9	5.0	4.2	4.2	4.4	4.7	4.2	3.2

TABLE 4

Mean dimensions of migrants, less those of sedentes of corresponding age (mm.)

	MALES					FEMALES
	II-I	III-I	IV-I	V-I	VI-I	VIII-VII
Stature	38.66*	35.09*	15.64	−8.31	22.92	21.58*
Sitting height	16.11*	17.65*	13.98*	3.30	14.82	18.42*
Biacromial diameter	12.82*	11.17*	13.63*	3.36	5.66	4.05
Chest width	8.41*	7.01	6.73	−2.80	6.93	2.77
Chest depth	−3.30	−1.83	6.50	−4.85	−0.06	—
Arm length	9.40	8.82*	10.43	1.22	−2.74	2.76
Radius length	4.95*	3.02	2.37	1.48	−0.07	1.20
Hand length	2.94	1.88	0.70	−1.75	2.00	1.48
Hand breadth	3.62*	2.02*	1.60*	−0.25	0.20	0.83
Tibia length	6.42	6.44*	2.74	−5.64	5.47	1.90
Foot length	5.63*	4.60*	3.10	−1.22	3.40	4.34*
Head length	−0.20	0.69	2.86*	−0.02	1.14	0.47
Head breadth	1.83	0.51	0.67	0.20	−0.07	−0.60
Head height	0.85	0.75	0.72	0.14	−0.33	−0.23
Minimum frontal diameter	1.36	0.28	1.66*	−0.34	2.66*	0.10
Bizygomatic diameter	3.10*	0.96	2.36*	1.04	1.47	0.90
Bigonial diameter	0.81	−0.02	0.74	−0.14	−1.60	0.78
Total facial height	3.42*	2.56*	1.56	−1.68	2.00	0.51
Upper facial height	2.93*	3.04*	1.62	−0.82	3.54*	0.33
Lower facial height	0.11	−0.25	0.46	−1.40*	−1.43	−0.30
Nose height	1.85*	1.39*	0.40	−1.03	0.53	1.48*
Nose breadth	0.39	−0.91	0.86	1.00*	0.26	−0.57
Mouth breadth	−0.80	−0.95	0.60	−0.07	1.50	0.20
Interocular width	0.83	0.20	0.79	0.39	0.93	−0.03
Ear breadth	1.05	0.29	0.77	−0.50	−1.27	−0.11
Ear height	−1.45	−1.15	0.23	−2.20	−0.20	1.70*

* Difference equals 2 or more times its standard error.

II. *Male migrants who first went to the United States before the age of 17 and who stayed 2 or more years.* This group not only migrated to the United States at an earlier age than any other group, but on the average they stayed there at least twice as long (16 years each). They therefore would be expected to show to a maximum extent an "environmental growth factor." In fact, this proves to be the group with the largest mean measurements in respect to 14 of the 26 dimensions considered, and next to the largest in respect to 9 others. The only exceptions are minimum frontal diameter, interocular width (both dimensions in which variability in technique is high) and head length. In respect to every measured dimension this group is, on the average, larger than the sedentes; in 10 of the measurements the difference is statistically significant. When compared to sedentes of comparable age, this series exceeds them significantly in 11 dimensions.

III. *Male migrants who first went to the United States between the ages of 17 and 27 and who stayed 2 or more years.* This group is also one which, under the assumptions, would tend to show the effects of an "environmental growth factor" but not to the same extent as migrants who first left home at an earlier age. In fact it is found that this group exceeds the sedentes, on the average, in every measured dimension but minimum frontal diameter and interocular width (both measurements which, as noted above, also tend to be small in other migrants who first went to the United States when young and who stayed two or more years). In 10 of the measurements the excess over the sedentes is statistically significant. Furthermore, in comparison with those migrants who first went before the age of 17 for 2 or more years, those who first went between the ages of 17 and 27 are smaller on the average in respect to every measured dimension except head length; only in bizygomatic diameter is the difference great enough to be statistically significant, however.

IV. *Male migrants who first left for the United States between the ages of 15 and 27 but who stayed only one year.* Under the assumptions, this group would be expected to show both the effects of any selective migration and of any "environmental growth factor" in their physique, but because of the short period of their stay in the United States, the latter factor would not be expected to be as important as in either of the two groups of migrants previously discussed. This group tends to be large in a number of dimensions. On the average they exceed the sedentes in respect to every measurement except ear height (a dimen-

sion in which increase with age is an important factor in this case). In respect to biacromial diameter, sitting height and minimum frontal diameter, this group significantly exceeds sedentes. Because of the young average age of this group, comparison with sedentes of strictly comparable age shows the former to exceed the latter in every measured dimension, significantly so in 6 dimensions.

When compared to the group of migrants who went to the United States before the age of 17 for 2 years or more, this group of individuals who stayed only one year tend to be either similar or smaller in most respects. They are significantly smaller in respect to nose height and hand breadth. On the other hand, when compared to individuals who first went to the United States at about the same age but who stayed for longer periods of time, there are no significant differences whatever.

As this group of men who stayed for only one year were mostly contract laborers recruited in Mexico, they would be expected to show to a maximum extent any effects of selection of larger physical types. Their intermediate status therefore supports the great importance of an environmental factor. It may be noted, however, that the close similarity of this group to those who had been in the United States at the same age but for longer periods of time, although in no way contradicting the probability of an environmental factor operating during growth, leaves open the question whether there may also have been some smaller influence of a selective factor during the period of labor contracting since 1943.

V. *Male migrants who first went to the United States at the age of 27 or later and who stayed one year.* As it is assumed that there is no appreciable effect of environment on bony dimensions after the mid-twenties at the latest, differences between this group and sedentes would be ascribed to selection. In fact this group is, in general size, more similar to the sedentes than the migrant groups so far considered. It will be seen that this group is significantly larger than sedentes in bizygomatic diameter, nose width, and mouth width. It is interesting that Goldstein also commented on the greater breadth of the face in emigrant Mexicans and their children as compared to sedentes. He said: "It might be said that this result, especially as regards the bizygomatic diameter, is suggestive of more Indian in our emigrant samples than in the group from Mexico proper. This is possible, of course, but it would seem unlikely that such could be the case in enough of the families measured to affect appreciably the averages . . ." Although this factor

would not apply to Goldstein's data, the greater facial breadths in the present subseries of migrants is associated with a somewhat greater mean age. Nose breadth, mouth breadth and bizygomatic diameter are all measurements which show a constant tendency to increase with age (Lasker, 1953). When allowance is made for the factor of age, the only significant difference between this group of migrants and sedentes is in the larger nose breadth of the former and the larger lower facial height of the latter.

VI. *Male migrants who first went to the United States at the age of 27 or later and who stayed 2 years or more.* This small group of individuals would, under the assumptions, manifest the same selective factors and in similar degree as those who went at the same ages but stayed only one year. It is interesting to analyze them separately only because whereas the latter group are mostly contract laborers and are of intermediate age, those who went when fully adult and stayed several years are mostly the earlier migrants who went at a time when any selection must have been self-selection, and at the time they were measured, they were considerably older on the average than any other subgroup.

This factor of age may account for the minor differences between this group and the last. The older group has significantly greater ear height and a tendency to be larger in chest dimensions and in most facial dimensions. In longitudinal dimensions which involve the limbs and trunk, the tendency is, if anything, to smaller size.

When compared to sedentes, these migrants who left for several years when already 27 years old show similar tendencies to the previous group. If anything, they are smaller than sedentes in general size, but exceed them significantly in bizygomatic diameter, nose and mouth breadths, chest dimensions and ear dimensions. A comparison with sedentes of the same ages, however, indicates that these differences can be adequately explained by the age factor: when comparison is made with sedentes of corresponding ages, the only significant difference is in minimum frontal diameter.

If the individuals who migrated after the age of 27, whether for a longer or shorter period of time, are compared with those who migrated before the age of 27 and who stayed in the United States 2 or more years, it is seen that the latter significantly exceed or tend to exceed the former in almost all measured dimensions. Under the assumption that all migrants would reflect any "physical selection" while only the latter

would reflect "environmental growth factors," it follows that the differences in size of the migrant groups are to be ascribed to some factor or factors of the environment in the United States operating during the growth period of the individual (i. e., before the age of 27) and that selective migration, if it influences this process at all, is too small a factor to be identified in a study of the present scope.

VII and VIII. *Females.* Although the total number of female migants measured is small, this group, each of whom spent two or more years in the United States, usually when young, is similar to the female sedentes but significantly exceeds them in stature, sitting height, and some other respects. Correction for the age factor in the female series does not add or subtract from the list of significant differences. In general, the data for the females therefore tend to confirm those for the males.

Comparison of Pairs of Brothers. One of the criticisms which might be leveled against comparison of the means of various subgroups is that the genetic factor is controlled only as to community membership. It might seem preferable to compare migrants with their own sedente brothers. Variability is largely intrafraternal, however, and as was found after trying it, comparison of brothers is not especially efficient statistically and does not yield significant conclusions in this study.

In most families where one brother had been to the United States, the other brothers had also migrated. Despite the consequent small size of the useful series, it may be of interest briefly to discuss the results of an analysis of pairs of brothers with different migrational histories (see Table 5). Of the males examined, 124 in 54 different sibships have brothers who were also measured. One hundred pairs of brothers are possible:

a. 15 pairs are between sedentes and their brothers who first migrated when over 27 years old (V-I and VI-I).

b. 16 pairs are between sedentes and their brothers who first migrated before the age of 27 (II-I, III-I, and IV-I).

c. 15 pairs are between men who first migrated before the age of 27 and their brothers who first migrated after that age (II-V, III-V, IV-V and III-VI).

d. 19 others pairs are between brothers both of whom first migrated before the age of 27 but one of whom went for a longer period of time or at an earlier age (II-III, II-IV, and III-IV).

TABLE 5

Differences between pairs of brothers (mm.)

	STANDARD DEVIATION		MEAN DIFFERENCE	
	Based on all brother pairs (a+b+ c+d+ e+f)*	Based on brother pairs with identical migrational status (f)	Selective migration factor (a)	Environ-mental migration factor (b+c+d)
Number of pairs	84-100	22-24	12-15	40-50
Age (years)	9.23	6.17	2.80	−2.02†
Stature	60.0	58.1	−11.86	2.18
Sitting height	33.2	30.9	1.15	−0.88
Biacromial diameter	19.7	21.0	2.93	−2.20
Chest width	24.4	33.1	3.80	−3.39
Chest depth	23.7	30.6	− 5.07	−2.68
Arm length	34.5	39.3	− 1.79	−2.32
Radius length	15.0	19.3	6.20	−1.78
Hand length	8.41	8.83	0.21	−1.36
Hand breadth	3.85	4.44	− 0.47	−0.14
Tibia length	25.7	37.9	− 4.73	2.56
Foot length	11.4	12.6	− 1.87	2.19
Head length	6.78	6.78	3.47	0.30
Head breadth	6.32	5.01	2.13	−1.04
Head height	6.23	4.18	− 0.67	0.46
Minimum frontal diameter	4.90	3.59	1.80	−0.38
Bizygomatic diameter	5.66	4.27	3.20†	−0.64
Bigonial diameter	6.91	5.88	− 2.40	−1.46
Total facial height	6.92	6.33	1.53	0.30
Upper facial height	4.93	5.05	− 1.50	0.60
Lower facial height	4.76	4.15	− 2.17	−1.47†
Nose height	3.35	3.55	0.20	−0.64
Nose breadth	3.43	2.78	0.33	−1.30‡
Mouth breadth	4.37	4.93	1.80	0.54
Interocular width	3.10	2.22	0.60	−0.80†
Ear breadth	3.48	2.52	0.87	0.48
Ear height	5.44	4.47	− 1.13	−0.54

* a, b, c, d, e, f. See text pp. 283, 285 for description of types of pairs.

† Yields significant *t* score at 5% level, but only on basis of standard deviation from pairs of brothers with identical migrational status.

‡ Yields significant *t* score at 1% level on basis of either value for standard deviation.

e. In 11 pairs both brothers had the same type of migrational history but with slight differences (II-II, III-III, and V-VI).

f. 24 pairs are between brothers both of whom had the same migrational histories or both of whom were sedentes (I-I, IV-IV, and V-V).

Standard deviations for brother pairs are calculated twice. First, all 100 brother pairs are used and this has the advantage of being based on the largest possible sample. Second, only pairs with identical histories (f) are used and this has the advantage of excluding the variable under investigation, effect of migration, from this statistic.

Differences in two sets of brother pairs are tabulated: first to test the hypothesis of selection, those who migrated after the age of 27 are compared with their sedente brothers (a); second, to test the hypothesis of environmental factors, those who migrated before the age of 27 are compared with their brothers who had been in the United States at a later age, for a shorter period of time, or not at all (b, c, and d). Using both sets of figures for the standard deviation, there are, for the 26 measurements and age, 4 comparisons for each or 108 comparisons in all. The *t*-scores of 5 of these reach statistical significance at the 5 per cent level and only one reaches the one per cent level.

It is apparent that the grouping by brothers lends no support to the hypothesis of either a selective or an environmental factor. The differences observed between brothers might well be explained as a chance distribution. This does not, however, detract seriously from the significance of the findings on unpaired data. The number of brother pairs is small; the number of degrees of freedom is even smaller because the majority of pairs contain individuals who are also counted in other pairings. There are too few data to imply that the difference previously noted for unpaired data are not applicable to brothers.

It may be noted in Table 5 that the values of the standard deviation for the 26 measurements by both calculations on brothers are, in every dimension, similar to or above the corresponding values based on the unpaired sedente subgroup given in Table 3. Comparison of *F*-scores reveals no case in which a dimension is statistically less variable (at the 5 per cent level of probability) in the paired data than in the unpaired sedente or pooled migrant series; this, despite the fact that brothers are significantly less variable in age. Variability in all dimensions is therefore intrafamilial rather than interfamilial.

CONCLUSIONS

The Physical Selection of Migrants. Individuals who first migrated to the United States after the age of 27, although they would be expected to show the effects of selection as much as, if not more than, those who went at a younger age, differ little from their own sedente brothers or from others who never left Mexico.[1]

Although migrants who first went to the United States after the age of 27 are, on the average, larger than sedentes in bizygomatic diameter, nose breadth, mouth width and perhaps, to a lesser extent, several other dimensions, these are all respects in which older sedentes exceed younger ones. If due allowances are made for age, there is little significant difference in dimensions between sedentes and migrants who first left Mexico after the age of 27.

Age at Migration and the Length of Stay in the United States. Those migrants who first went to the United States before the age of 27 are significantly larger in many respects than those who did not. Those who went before the age of 17 show even larger dimensions in almost every respect than those who first went between the ages of 17 and 27. However, they also stayed longer in the United States, so it is not clear whether the age at which they went or the length of stay is the more important factor. In any case it would appear that during the last years before epiphyses close, environmental factors are increasingly important relative to the amount of growth taking place. Of those who went between the ages of 17 and 27, those who stayed only one year (one individual who went 2 years earlier is included) differ little from those who stayed two or more years. It should be noted, however, that among those who first went to the United States between the ages of 17 and 27 and who stayed several years, only a fraction of their stay may have been made before they reached the age of 27. The data are there-

[1] On the other hand, it may be argued that it is precisely among minors that larger individuals would tend to get through the immigation barrier and that selective factors would be at a maximum in the same age groups as would environmental factors. If that were true the two factors could not be distinguished in such a study as this. Two circumstances tend to minimize this argument, however. First, some of those who migrated when young accompanied their parents and any selective mechanism must have been very indirect and minor. Secondly, even if large adolescent boys were selected they would, for the most part, be early maturing individuals whose superiority in size would not be expected to be maintained undiminished into adulthood.

fore insufficient to make it possible to determine whether the differences noted are proportional to the length of stay in the United States.

Environmental Growth Factors. There is thus evidence to support the hypothesis that the migrants who went to the United States while young had different environmental influences affect their growth there in such a way as to be manifest in a general increase in size. The evidence does not indicate any appreciable effect of selective migration. In fact, male sedentes in Paracho may be thought of as pre-migrants rather than non-migrants; for the most part they are merely individuals who have not yet happened to go to the United States.

As to the nature of the environmental factor or factors which are important, the present study serves to indicate the possibilities. The fact that the chest dimensions of migrants exceed those of sedentes, rather than the reverse, makes it unlikely that altitude and rarified atmosphere are of major importance. Similarly, there is nothing to indicate any contrast in temperature, humidity or other climatic factor which might be significant. The effect of different occupations, if any, would be expected to be manifest in muscularity. This was not measured, but data on such features as hand size suggest the possibility of occupational factors. As for diet, moreover, that of the Mexican emigrants to the United States may well have been quantitatively more adequate, at least when compared with that of sedentes during times of stress in Mexico. The differences actually observed are not satisfactorily explained as the results of differences in the amount of fat deposited and this is more apparent when the age factor is taken into consideration. The effect of more abundant diet on the still-growing individuals, however, is probably a significant factor in the eventual size of migrants. This theory would be consistent with the significant differences found between migrants and sedentes in a wide variety of measurements, especially in those which best reflect general size.

SUMMARY

Comparisons of measurements taken in Paracho, Michoacán, of 185 male and 23 female adult Mexicans who had been in the United States for various periods of time, with measurements of 111 male and 158 female non-migrants indicate that:

1. In general migrants of both sexes are larger in various dimensions than sedentes.

2. Among male migrants, those who went to the United States for longer periods of time at younger ages are, on the average, larger in most respects than those who went when older.

3. With the exception of a few dimensions, the findings concerning which can be ascribed to age differences, there is little difference in any dimension between males who never left Mexico and male migrants who first went to the United States after the age of 27.

4. Analysis of 100 pairs of brothers in the series reveals no more significant differences than would be expected by chance. However, the pairs include only 15 in which one brother migrated when 27 or over and the other not at all, and only 50 in which one brother went while younger or for a longer period of time than the other.

5. The factor of selective migration might be assumed to influence those who went to the United States after the age of 27 at least as much as those who went at younger ages, while environmental growth factors would be expected to affect especially those who first went while they were still growing. Therefore the present findings lend no support to the hypothesis of an appreciable physical selection of the migrants in this study, but confirm the existence of environmental growth factors acting on Mexican emigrants to the United States. It is suggested that a more abundant diet in the United States may be a major factor of this kind.

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NORTH AMERICAN NEGRO INFANTS: SIZE AT BIRTH AND GROWTH DURING THE FIRST POSTNATAL YEAR

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A RECENT seminar of physical anthropologists placed special emphasis on "the need for the derivation of more generalizations from growth studies" [21, p. 32]. It is unequivocal that generalization is one of the steps in scientific method [9] and, consequently, that those who study growth fall short of their full responsibility as scientists whenever they fail to take this step. Notwithstanding, generalization calls for scholarly judgment and close attention to the caliber and scope of the body of fact being subsumed. Lacking direct and critical reference to the dependability of the items that constitute its research foundation, it reduces to a useless and often detrimental product. Witness the unsound generalizations regarding human growth that have found their way into textbooks and teaching and proven difficult to counteract, e. g., alternating spurts of horizontal and vertical growth [30], constancy of the individual's stature rank in his age group [26], later eruption of deciduous teeth in males than in females [29], and earlier age of puberty in the tropics [16].

Since generalization is an integral part of scientific method, it is pertinent to inquire into the source of the existing "need for the derivation of more generalizations from growth studies." When a problem is first studied the scientist's task of generalizing lies within the bounds of a single investigation, i. e., within the frame of the specific set of sampling, collection, and analysis operations he has employed. For some time after the initial study, those who gather additional original data on the problem find it practicable to review all prior work and derive generalizations that take full account of the composite factual base. As the quantity of literature on a topic becomes extensive, however, descriptive accounts of the collection and statistical reduction of

new materials tend to "exclude citation of previous findings on the problem, or make comparisons among only a small number of the relevant investigations" [28, p. 1]. Thus there develops a lag in cumulative generalization—and a need for research contributions in which the central objective is that of assembling all available studies on a topic and generalizing at the highest warranted level of precision and completeness. This type of research report serves to complement the types otherwise accessible by providing generalizations that are less equivocal (more substantial) or broader in scope (more comprehensive), and by discovering previously unrecognized relationships. Recent work on secular variation [28, pp. 11-15; 34] illustrates the derivation of new generalizations through composite integration and alignment of sets of existing studies.

It is the writer's view that the development of many problems of human growth has reached the stage where papers focused solely on synthesis have an indispensable place. The present paper will cite an instance and provide the needed synthesis. For the instance it will suffice to make brief reference to two generalizations pertaining to North American Negro neonates. Both have been published within the last decade. The one reads: "The birth weight of Negroes is smaller than that of whites" [33, p. 299]; and the other: "Negroes in favorable social and economic conditions tend to be . . . comparable to whites at birth" [24, p. 12]. How is the human biologist to fit these statements into his working knowledge of growth? Where does the path of sound interpretation lie? What can be taken for dissemination purposes as valid generalizations with regard to differences in the body size of North American Negro and white infants?

The needed synthesis—viewed in its relevant setting—calls for the treatment of two topics: (1) size at birth and (2) growth during the first postnatal year. Together, these topics furnish an interlocking perspective on North American Negro and white differences as they stand at the end of the intrauterine period and as they change during early postnatal life. The section on size at birth will include materials up to the eighth postnatal week, while the section on growth during the first year of infancy will deal with materials for the four successive quarter-year ages from 3 months to 1 year.

SIZE AT BIRTH

Attention will be given to body weight, stature, stem length, length of trunk, head circumference, circumference of thorax, head breadth and breadth of hips. There are 18 studies on North American Negro infants in which findings for weight at birth are reported, plus 5 others that afford weight findings at ages 3 to 6 weeks. The available investigations for stature number 5 at birth, with 4 additional at ages younger than 2 months. For the remaining measurements, there is further reduction to 2 neonatal studies on trunk length and one on each of the others.

The first step will be to present individual studies and display their separate findings on the average size of North American Negro and white neonates. In order to proceed as expeditiously as possible, a succinct characterization of the samples follows, while each *N* and central tendency value is directly tabled in convenient form for later use.[1] Table 1 carries the statistics for weight and Table 2 those for the other measurements.

Riggs [43] analyzed weight and stature data amassed on Negro and white infants between 1896 and 1904 by the Department of Obstetrics, Johns Hopkins Hospital, Baltimore. The data were obtained "within an hour" after birth and excluded records from "premature labors and abortions, multiple pregnancies," and infants measuring less than 40 cm. in length (pp. 422-423). Birth weight and stature measurements from the same source, accumulated between 1896 and 1910, were subjected to study by Meyer [32]. In this analysis all records were rejected in which the pregnancy period (calculated from the beginning of the last menses to parturition) was less than 34 weeks or more than 46 weeks.

Three investigators—Baldwin [6], Tyson [48], and Bakwin [2]—published means for weight at birth from samples of Negro and white infants born between 1910 and 1930. Baldwin's series were infants born at Baltimore in the period 1910-13 and later under pediatric supervision throughout their first year at the Baby Milk Fund Association of Baltimore; Tyson's were "full-term babies" born 1925-27 at the Philadelphia Lying-in and Jefferson Medical College Hospitals; and Bakwin's were infants from "poverty-stricken" neighborhoods of New York City born 1928-29 at Bellevue Hospital.

Weight means were obtained by Peckham [38] for Negro and white newborn infants having attained either a weight of 2.5 kg. or a length of 45 cm. The records were drawn from the 1896-1930 files of the Department of Obstetrics, Johns Hopkins Hospital, on "patients registered for prenatal care in the hospital dispensary and subsequently delivered of a viable child" (p. 325). Birth weight averages also were reported by Bivings [8] for normal, nonsyphilitic Negro and

[1] Wherever possible the values tabled represent both sexes combined. Those studies which dealt with one sex only are grouped separately and so captioned.

TABLE 1

Neonatal weight means (kg.) for North American negro and white infants

INVESTIGATION	NEGRO		WHITE		NEGRO MEAN LOWER BY:
	N	Mean	*N*	Mean	
		Weight at birth: Both sexes			
1. Riggs	721	3.07	779	3.31	0.24
2. Meyer	1 027	3.19*	1 031	3.44*	0.25
3. Baldwin	130	3.37	138	3.67	0.30
4. Tyson	307	2.95	269	3.06	0.11
5. Bakwin	187	3.01	1 217	3.32	0.31
6. Peckham	14 000†	3.26	12 000†	3.48	0.22
7. Bivings	3 255	3.12	1 801	3.40	0.28
8. Dunham, et. al.	154	3.09*	2 769	3.40*	0.31
9. Duffield, et. al.‡	7 352	3.15	89 879	3.33	0.18
10. Duffield, et. al.§	6 598	3.27	84 769	3.40	0.13
11. Anderson, et. al.‡	2 297	3.10	3 389	3.29	0.19
12. Anderson, et. al.§	1 692	3.23	2 741	3.39	0.16
13. Michelson	929	3.20	270	3.40	0.20
14. Pasamanick; Norval, et. al.	53	3.31	691	3.38	0.07
15. Scott, et. al.; Meredith and Brown	10 692	3.32‖	4 545	3.40	0.08
16. Kessler and Scott; Gunstad and Treloar	300	3.27	4 833	3.40	0.13
		Weight at birth: Males only			
17. Freeman and Platt	47	3.33	116	3.38	0.05
18. Rhoads, et. al.	99	3.25	134	3.32	0.07
		Weight at ages 3 to 6 weeks: Both sexes #			
19. Kelly and Reynolds	33	3.45	74	3.63	0.18
20. Scott, et. al.; Peatman and Higgons	491	3.98	279	4.13	0.15
21. Woodbury	174	4.34	2 791	4.77	0.43
22. Dodge; Rude	62	4.11	28	4.52	0.41
23. Bakwin and Patrick; Bakwin and Bakwin	79	4.21	144	4.42	0.21

* Medians. † Approximate *N*'s.

‡ Live-born infants. § Infants weighing over 2.5 kg.

‖ The mean for both sexes together is given by Scott, Jenkins and Crawford as 3.34 kg. This exceeds the mean derived from their statistics on each sex.

\# Row 19, age 3 weeks; row 20, age 1 month; rows 21 to 23, age 6 weeks.

TABLE 2

Neonatal means for stature and six measures of the body stem (cm.) on North American Negro and white infants

INVESTIGATION	NEGRO		WHITE		NEGRO MEAN LOWER BY:
	N	Mean	*N*	Mean	
Stature at birth: Both sexes					
1. Riggs	721	48.4	779	49.7	1.3
2. Meyer	1 027	48.5	1 031	49.8	1.3
3. Pasamanick; Norval, et. al.	35	50.1	691	50.9	0.8
4. Kessler and Scott; Gunstad and Treloar	300	49.8	1 767	50.4	0.6
Stature at birth: Males only					
5. Freeman and Platt	47	49.1	116	49.5	0.4
*Stature at ages 3 to 8 weeks: Both sexes**					
6. Kelly and Reynolds	32	51.6	74	53.3	1.7
7. Scott, et. al.; Peatman and Higgons	333	53.3	279	54.5	1.2
8. Woodbury	174	54.7	2 791	56.4	1.7
9. Michelson	152	56.5	128	58.6	2.1
Trunk length† at birth: Males only					
10. Freeman and Platt	47	18.1	116	18.5	0.4
Six dimensions of the body stem at age 3 weeks: Both sexes					
11. Kelly and Reynolds:					
Length of stem‡	31	34.5	68	35.9	1.4
Length of trunk	33	21.3	74	22.1	0.8
Girth of head	33	35.2	74	35.8	0.6
Girth of thorax	33	32.6	74	33.5	0.9
Width of head	33	9.8	74	10.0	0.2
Width of hips	33	8.8	74	9.2	0.4

* Row 6, age 3 weeks; row 7, age 1 month; row 8, age 6 weeks; row 9, age 1.9 months.

† Suprasternale to os pubis.

‡ The measurements are defined as vertex-rump distance, distance from top of shoulders to coccyx, maximum fronto-occipital circumference, circumference of chest at level of nipples, biparietal diameter, and bi-iliocristal diameter.

white infants of correspondingly low socioeconomic level born in 1932 at Grady Hospital, Atlanta, Georgia, and by Dunham, Jenss and Christie [14] for Negro and white infants of Connecticut "born alive in the New Haven Hospital during the five-year period 1928-32" (p. 156).

Duffield, Parker and Baumgartner [13] analyzed Negro and white weight data from "live-birth certificates recorded in New York City in 1939" (p. 123). Infants were considered born alive "if there was a sign of life after complete separation of the body of the child . . . whether the cord was or was not cut" (p. 123). Analyses are available from this study for the weight distribution 1.0 kg. to 5.0 kg. and for the more restricted distribution 2.5 kg. to 5.0 kg.

A similar investigation by Anderson, Brown and Lyon [1] was based on weight records for "consecutive live-born infants not the result of multiple pregnancy born in the obstetric wards of the Cincinnati General Hospital from July 1938 to January 1941" (p. 524). Means were given for the total live-born series and for the sub-series 2.5 kg. and up. The Negro and white samples were considered to represent "approximately the same economic status" (p. 524).

Michelson [33] published stature and weight means on Negro and white neonates measured 1935-36 in New York City. The Negro subjects were born to mothers "living in Harlem" and receiving "prenatal care" at the district clinics of the "Department of Health of the City of New York" (p. 290). The white mothers received the "same care" and were from "lower middle class" homes (pp. 204, 298). Means for weight are given at birth, but the earliest age represented by means for stature is 1.9 months.

Pasamanick [36] analyzed stature and weight records obtained at birth on a series of Negro infants born 1944 at New Haven, Connecticut, and later "regularly seen" at well-baby clinics of the New Haven Board of Health. For alignment with this sample, there is a sample of white infants born 1934-44 at Rochester, Minnesota, and later enrolled in Rochester well-baby clinics [35]. The Negro mothers "almost all . . . received prenatal care in one or other of the clinics available in New Haven, with supervision of and instruction on prenatal diet" [36, p. 37]; the white mothers, similarly, had access to "excellent prenatal . . . care" [35, p. 278]. Economically, the Negro families were "average or below average" and the white families "average or somewhat above average."

Weight at birth was studied by Scott, Jenkins and Crawford [46] on full-term Negro infants delivered 1939-47 at Freedmen's Hospital, District of Columbia. A comparative series of full-term white infants is obtainable from Meredith and Brown [31] by combining the samples of Cates and Goodwin, Faber, Griffith and Gittings, Holt, Meredith and Brown, Taylor, and Yerington.

Stature and weight means are available from Kessler and Scott [23] on Negro infants born 1948-49 at Freedmen's Hospital, District of Columbia, and from Gunstad and Treloar [19] on white infants born 1927-32 at the Minneapolis General Hospital, Minnesota. The infants included in the Negro sample were "single born" and weighed 2.2 kg. or more, while the white sample comprised infants from "uniparous births . . . regardless of their adjudged stage of maturity" (p. 567). Both investigations made analyses according to "hospital pay status"—Gunstad and Treloar used the subgroups private and non-private, Kessler and Scott the subgroups private, ward pay, and free—and both failed to

obtain statistically significant differences. To quote Kessler and Scott: "No consistent variation . . . with economic status was found" [23, p. 377].

Studies by Freeman and Platt [17] and Rhoads, Rapoport, Kennedy and Stokes [41] afford means at birth on males only. The earlier study supplies values for weight, stature, and trunk length on normal Negro and white males born at the Sloane Maternity Hospital, New York City. The white sample comprised offspring from widely dispersed European groups. Values for weight alone are furnished in the later study and its subjects are Negro and white males born 1936-38 at the Children's Hospital of Philadelphia. All weighed 2.2 kg. or more and were from families of "low income status." The white sample was "in large proportion of northern European stock, with approximately one-fourth of Italian descent" and the other sample "an urban cross section of American Negroes."

An investigation by Kelly and Reynolds [22] carries means for weight, stature, stem length, trunk length, head girth, chest girth, head width, and hip width representing 3 weeks postnatal age. The subjects were Negro and white infants of both sexes born 1933-36 at Detroit, Michigan, to parents of "low" socioeconomic status.

Stature and weight means at age 1 month are available from Scott, Cardozo, Smith and DeLilly [45] on Negro infants and from Peatman and Higgons [37] on white infants. All were full-term infants under private pediatric care. The Negro sample was drawn from families of the "lower middle class" residing in the District of Columbia, 1940-47; the white sample was amassed a decade earlier in areas suburban to New York City, the families ranging from lower middle to upper class and from northern to southern European extraction.

At 6 weeks postnatal age stature and weight means are supplied by Woodbury [50] on Negro and white infants judged by physicians as negative for physical defects and symptoms of illness. The data were collected 1918-19 through a "Children's Year" campaign promoted by the Children's Bureau and the Woman's Committee of the Council of National Defense. The Negro group was considered to typify a socioeconomic level somewhat lower than that of the white group.

Finally, two additional comparisons are available for mean weight at age 6 weeks. One is on Negro infants studied by Dodge [12] at Cleveland, Ohio, and on white infants studied by Rude [44] at Gary, Indiana. The Negro infants were examined 1914-20 at a "Prophylactic Dispensary." While they were from homes "in a congested district," cases of "lues, tuberculosis, prematurity, decomposition, stationary weight, and spasmophilia were excluded" [12, p. 339]. The white infants were examined 1918 at baby health conferences; over 60 per cent were from homes with an annual income below $1,500 and over 40 per cent were of eastern or southern European ancestry. The other comparison is for Negro [5] and white [3] infants "from moderate income families" of New York City. Both groups were enrolled for systematic pediatric supervision, the Negro group in private practice and the white group at the well-baby clinic of the Fifth Avenue Hospital. The latter sample was characterized as largely of northwest European, Mediterranean, and Jewish lineage.

The first step in development of the "Size at Birth" section of the paper now is completed. Tables 1 and 2 show that in every instance the

averages for Negro neonates are smaller than those for white neonates. The next step will be to integrate the collected materials for body weight.

The aggregate numbers of newborn infants of both sexes included in Table 1 are 39,656 and 121,801 for Negroes and whites respectively. These are the *N* totals for investigations 3 through 9, 11, and 13 through 16.[2] Means derived from the two poolings are 3.23 kg. and 3.35 kg., indicating that North American Negro infants are lighter at birth than North American white infants by 0.12 kg. or 3.6 per cent.

Composite findings representing American Negro and white infants weighing more than 2.2 kg. at birth may be secured by amalgamating the materials from investigations 4, 6, 10, 12, 15 and 16. For the 33,589 Negro infants the mean is 3.28 kg., and for the 109,157 white infants it is 3.41 kg. These means are 0.05 kg. and 0.06 kg. higher than those of the preceding paragraph, and again the Negro value is lower than the white value by over 4 ounces and almost 4 per cent.

The weight difference registered by measures of central tendency is attested by various other statistics for Negro and white weight distributions. Peckham [39] provides several percentage comparisons from birth weight data on Negroes and whites born 1896-1935 at Johns Hopkins Hospital. Among 3,578 viable infants from single pregnancies weighing less than 2.5 kg., "yet at least 35 cm. in length," 69 per cent were Negroes and 31 per cent whites. In the total viable series of 21,043 Negro infants and 18,801 white infants, birth weights below 2.5 kg. were recorded for 13 per cent of the former and 7 per cent of the latter. Parallel percentages for the single births only were 12 and 6 respectively. A later study by Christie, Dunham, Jenss and Dippel [10] reports birth weights under 2.5 kg. for 15 per cent of 544 Negro infants and 10 per cent of 563 white infants. These samples were single-born, viable, non-syphilitic infants born at Johns Hopkins Hospital between 1936 and 1938.

The previously described studies by Dunham, Jenss and Christie [14] and Duffield, Parker and Baumgartner [13] supply information on Negro and white infants weighing less than 3.0 kg. at birth. The percentages of Negro infants below this weight were 43 in the first study and 37 in the second. Comparable percentages for the white infants were 21 and 24 respectively. Passing from the lower to the upper parts of the distributions, birth weights of 3.5 kg. or more were found by

[2] The reader is reminded that the subjects of investigations 1 and 2 are included in 6, and those of 10 and 12 in 9 and 11.

Christie, Dunham, Jenss and Dippel [10] for 15 per cent of their Negro sample and 35 per cent of their white sample.

Anderson, Brown and Lyon [1] published their frequency distributions on Negro and white infants having birth weights of 2.5 kg. or more. The 10th, 25th, 75th and 90th percentiles of these distributions differ in that the Negro values are smaller than the white values by 0.08 kg., 0.13 kg., 0.20 kg. and 0.22 kg., respectively.

Turning now to the measurements other than weight, the reader is asked to re-examine Table 2 and take note of the consistent direction of the differences for all items listed. That portion of the table which deals with measurements of the head and trunk is self-explanatory. It remains, then, to present a synthesis of neonatal materials for stature.

While the total stature materials are considerably less substantial than those for weight, they suffice to indicate that American Negro neonates are somewhat shorter than American white neonates. This can be shown more decisively by expanding on the central tendency findings of Table 2 and appending other statistics from stature distributions.

Attention first will be focused on the smallest difference in Table 2 among the 4 comparisons for newborn infants of both sexes (see row 4). Is it reasonable to assume that the true stature difference at birth between North American Negro and white infants is not less than 0.6 cm.? In other words, how dependable are the two figures which yield this difference? The white mean of 50.4 cm. is highly dependable. In an earlier synthesis of North American stature data for white infants of both sexes [28], means of 50.4 cm. were obtained on each of the following: a) 2,567 infants measured during the period 1910-25, b) 5,123 infants measured during the period 1926-41, c) 2,102 infants drawn mainly from the lower socioeconomic groups, and d) 1,122 infants representing the middle and upper socioeconomic groups (pp. 14, 29).[3] The Negro mean of 49.8 cm. possibly is higher than the true value for American Negroes. This is suggested by three observations: the figure exceeds the mean from Meyer's large sample, exceeds the mean from Freeman and Platt's male sample,[4] and is high in relation to the mean at 1 month from the study by Scott, Cardozo, Smith and DeLilly. It is considered a tenable inference that

[3] These findings for stature in relation to secular period and socioeconomic status should be interpreted as specifically characterizing the termination of prenatal life. Readers unfamiliar with the difference between neonatal and late infancy relationships will want to examine reference 28, pp. 11-15 and 27-38.

[4] Means from large samples of North American white infants of each sex have shown that males exceed females in stature at birth by 0.7 cm. [28, p. 43].

the true difference in mean stature for North American Negro and white newborns is at least 0.6 cm., and probably not less than 1.0 cm.

Continuing with examination of the stature materials in Table 2, it is seen that all four of the differences at ages 3 to 8 weeks exceed 1.0 cm. The smallest of the differences is for row 7; here the Negro mean is 53.3 cm. and the white mean 54.5 cm. The latter figure can be regarded a close estimate of the parameter value. This follows since a composite mean of 54.5 cm. is obtained for 6,226 North American white infants of like age (1 month) drawn from studies by Bayley and Davis [7], Davenport [11], Iowa Child Welfare Research Station [20], Kelly and Reynolds [22], Maresh and Washburn [25], Norval, Kennedy and Berkson [35], Richdorf [42], Rude [44] and Woodbury [50]. The Negro mean possibly overestimates the parameter a little. A basis for this view is found in the fact that Kelly and Reynolds report a mean at 6 weeks of 54.7 cm. (identical with the Woodbury mean at 6 weeks) which, when used in conjunction with their mean at 3 weeks, gives an interpolated value at 1 month 0.5 cm. lower than 53.3 cm. Generalizing, it can be claimed with high scientific confidence that the average North American Negro neonate is no less than 1.0 cm., or 2 per cent, shorter than the North American white neonate.

Further evidence of a systematic difference between Negro and white stature distributions at birth is accessible from Peckham [39] and Christie, Dunham, Jenss and Dippel [10]. The former found that a) among 2,162 viable infants each measuring less than 45 cm. in length but weighing at least 1.5 kg., 69 per cent were Negroes and 31 per cent whites, and b) statures of less than 45 cm. occurred in 8 per cent of viable Negro births in contrast with 4 per cent of viable white births. In the study by Christie and others, percentages of viable, single-born infants measuring less than 47 cm. at birth were 26 and 14 for Negroes and whites respectively. The same investigation also dealt with the upper portions of the stature distributions, finding that 20 per cent of the Negro sample and 43 per cent of the white sample had statures 50 cm. or more.

GROWTH DURING THE FIRST POSTNATAL YEAR

The same procedure will be followed as in the foregoing section. Initially, source materials will be described and central tendency values tabled. The latter will be given at the four selected ages, 3 months, 6 months, 9 months and 1 year. As before, figures for weight will be brought together in one table (Table 3) and figures for the other measurements in a second table (Table 4).

TABLE 3

Weight means (kg.) at selected postnatal ages for North American negro and white infants

INVESTIGATION	3 MONTHS		6 MONTHS		9 MONTHS		1 YEAR	
	N	Mean	*N*	Mean	*N*	Mean	*N*	Mean
			Infants of both sexes					
1. Baldwin*	90	5.07	82	6.57	73	7.50	63	8.40
	118	5.16	109	6.65	87	7.94	53	9.04
2. Woodbury	301	5.55	279	7.03	245	7.81	182	8.60
	7 046	5.86	7 238	7.46	7 152	8.45	6 476	9.20
3. Dodge; Rude	208	5.22	155	6.62	145	7.59	119	8.54
	85	5.66	96	6.94	78	8.05	101	8.69
4. Michelson	1 714	5.36	981	7.23	589	8.53	338	9.51
	180	5.87	219	7.76	167	9.24	100	10.35
5. Bakwin and Patrick;	102	5.68	97	7.63	99	9.14	95	10.26
Bakwin & Bakwin	218	5.72	164	7.63	115	9.10	90	10.35
6. Pasamanick;	53	6.40	53	8.15	53	9.48	53	10.55
Norval, et. al.	2 518	5.68	1 943	7.62	1 508	8.97	1 076	9.94
7. Kelly and Reynolds	108	5.50	100	7.48	84	8.86	46	9.75
	289	5.52	269	7.54	220	8.87	124	9.83
8. Scott, et. al.;	613	5.66	600	7.68	580	9.14	553	9.96
Vickers & Stuart	254	5.71	252	7.82	241	9.06	244	10.08
9. 1930-50 composite	2 590	5.47	1 831	7.44	1 405	8.88	1 085	9.87
	4 538	5.68	3 937	7.64	3 245	9.01	2 640	10.00
			Males only					
10. Rhoads, et. al.							99	9.98
							134	10.06

* In each comparison the upper figures are for American Negro infants and the lower figures for American white infants.

TABLE 4

Means for stature and six measures of the body stem (cm.) on North American negro and white infants

INVESTIGATION	3 MONTHS		6 MONTHS		9 MONTHS		1 YEAR	
	N	Mean	*N*	Mean	*N*	Mean	*N*	Mean
			Stature					
1. Woodbury*	301	59.1	279	64.6	245	67.7	182	71.3
	7 046	60.5	7 238	66.2	7 152	69.9	6 476	73.2
2. Michelson	153	60.0	135	67.0	98	70.9	68	74.7
	180	62.6	219	69.4	167	74.6	100	78.3
3. Pasamanick;	35	61.7	35	67.4	35	72.4	35	74.5
Norval, et. al.	2 518	59.2	1 943	66.2	1 508	70.6	1 076	74.5
4. Kelly and Reynolds	108	59.8	100	66.7	85	71.7	47	75.5
	286	60.4	268	67.0	219	71.6	124	75.5
5. Scott, et. al.;	419	59.5	434	66.7	421	71.4	424	75.3
Vickers and Stuart	243	59.9	241	66.3	232	70.8	234	74.9
6. 1930-50 composite	715	59.8	704	66.8	639	71.4	574	75.2
	4 488	60.2	3 691	66.8	3 210	71.4	2 650	75.2
7. Rhoads, et. al.†	99	59.0	99	66.2	99	71.1	99	74.8
	134	59.4	134	66.2	134	70.8	134	74.3
			Stem (crown-rump) length					
8. Kelly and Reynolds	104	40.0	100	44.1	85	46.8	47	48.4
	281	40.8	269	45.1	218	47.4	123	49.4
9. Rhoads, et. al.†	99	38.8	—	—	—	—	99	46.9
	134	39.5	—	—	—	—	134	47.5
			Trunk (shoulders-coccyx) length					
10. Kelly and Reynolds	107	24.6	100	27.4	85	29.1	47	29.9
	286	25.2	269	28.2	219	29.6	124	30.8
			Head circumference					
11. Kelly and Reynolds	107	39.6	99	42.8	85	44.9	47	46.1
	286	39.5	269	42.7	219	44.6	124	45.7
12. Rhoads, et. al.†	99	39.8	—	—	—	—	99	46.2
	134	39.9	—	—	—	—	134	46.4
			Chest circumference					
13. Kelly and Reynolds	107	38.2	99	41.7	85	43.8	47	45.1
	286	38.3	269	42.0	219	44.1	124	45.5
14. Rhoads, et. al.†	99	39.4	—	—	—	—	99	46.5
	134	39.9	—	—	—	—	134	47.2
			Width of head					
15. Kelly and Reynolds	107	11.0	100	12.0	85	12.6	47	12.9
	286	11.1	269	12.2	219	12.7	124	13.0
			Width of hips					
16. Kelly and Reynolds	108	10.6	100	11.8	85	12.7	47	13.2
	286	10.9	269	12.2	219	13.0	124	13.6
17. Rhoads, et. al.†	99	9.7	—	—	—	—	99	11.9
	134	10.1	—	—	—	—	134	12.6

* In each comparison the upper figures are for Negroes and the lower ones for whites.

† Male infants only.

Three studies are available on samples drawn between 1910 and 1920. Baldwin [6] obtained weight means for Negro and white infants under the pediatric supervision of physicians at the Baby Milk Fund Association of Baltimore in the period 1910 to 1914. From the total records on file, those used were for infants "who had been weighed at least monthly during the first year" (p. 36). Means for weight and stature were reported by Woodbury [50] on Negro and white infants examined during the Children's Year of 1918-19. These subjects were all judged by physicians to be negative for physical defects and symptoms of illness; it was noted, however, that the Negro sample probably represented a lower socioeconomic level than the white sample. Lastly, means for weight were reported by Dodge [12] on Negro infants studied 1914-20 at Cleveland, Ohio, and Rude [44] on white infants studied 1918 at Gary, Indiana. The Negro infants were examined at a "prophylactic dispensary" and the white infants at "baby health conferences." Two-fifths of the white group were of eastern and southern European ancestry and the majority from homes with an annual income below $1,500. Although the Negro group lived in a congested district, Dodge observed that "Negro living conditions and wage earnings were more on a par with those of the white population than in many other cities" and "Negro mothers were cooperative and faithful in fulfilling dispensary instructions" [12, pp. 338, 339].

Michelson [33] published means for stature and weight on Negro and white infants measured 1935-36 at New York City. The Negro data were amassed at "Department of Health Clinics in Harlem" and the white data on "lower middle class" infants seen by Dr. Nellie Marmor in private practice. Both groups of infants were "brought up on the same diet," the "scientific dietary regime as advocated by the Department of Health of New York City" (pp. 203, 298).

Weight means for New York City Negro and white infants from homes of "moderate income" are accessible in Bakwin and Patrick [5] and Bakwin and Bakwin [3]. Both groups received pediatric care during the first postnatal year and were prescribed an adequate milk formula, orange juice and cod liver oil from 3 weeks, vegetable or cereal by 3 to 4 months, and egg yolk by 3 to 6 months. The Negro infants were enrolled in Patrick's private practice and the white infants at the well-baby clinic of the Fifth Avenue Hospital. The latter were described as mainly of northwest European, Mediterranean, and Jewish lineage.

Pasamanick [36] studied a 1944-45 sample of Negro infants residing in New Haven, Connecticut, and Norval, Kennedy and Berkson [35] a 1934-45 sample of white infants residing in Rochester, Minnesota. Both groups received "excellent prenatal and postnatal care" at community obstetric and pediatric centers. The Negro infants were from families falling within the "average or below average economic group," while the white infants were "of average or somewhat above-average economic status" and "predominantly of North European ancestry." Means for stature and weight are provided by each investigation.

Analyses for all of the measurements under consideration are available from Kelly and Reynolds [22]. Their subjects were Negro and white infants living in homes of low economic status but receiving exceptional nutritional care. Both samples represented "the indigent and near-indigent class" of Detroit, Michigan, in the decade following 1933. The mothers were instructed at a clinic and by visiting nurses in feeding management and health protection. Regular pediatric examinations were made, and throughout their first year the infants (all free

from "congenital or inherent abnormality") were prescribed "a carefully balanced artificial diet . . . and the chief elements supplied gratis to the parents" (p. 479).

Stature and weight means under conditions of pediatric supervision and average economic status are reported for Negroes by Scott, Cardozo, Smith and DeLilly [45] and for whites by Vickers and Stuart [49]. The Negro data were collected 1940-47 on infants of "lower middle class" observed "throughout the first year" in "the private practice of three pediatricians" (p. 885). The white data were accumulated 1930-40 on infants reared "in the vicinity of Boston in homes of low to middle economic circumstances" and brought to a pediatric center for "pediatric health and nutritional advice" (p. 156).

Rhoads, Rapoport, Kennedy and Stokes [40, 41] analyzed data for weight, stature, "head circumference, chest circumference, pelvic breadth, and crown-rump length" gathered on Negro and white male infants cared for in homes "of low income status" with the aid of a free clinic program of "regular medical supervision." The data were amassed in Philadelphia 1936-39 under conditions of directed artificial feeding and "good maternal cooperation." Each home was visited "every two weeks in order to deliver the evaporated milk and vitamin supplements, and to keep in touch with the home care of the child" [41, p. 417]. To the basal diet of evaporated milk, orange or tomato juice, and supplementary vitamin D, "banana and cereal were started at 3 to 4 months, pureed vegetables and fruits at 5 to 6 months, and potato and meat at 8 to 10 months" [40, p. 171]. The white subjects were predominantly of northwest European descent, with one-fourth of Italian extraction and one-fifth of Slavic and mixed European lineage.

Interpretation of the materials assembled in Tables 3 and 4 requires attention to a wider range of research controls than was the case for Tables 1 and 2. This arises from the increased complexity and more differential expression of variables influencing body size in the first year of postnatal life than during the prenatal period. To illustrate: while the previously mentioned synthesis on stature [28] gave identical means at birth for white infants studied 1910-25 and 1926-41, the secular means for the last half of the first year were substantially different and led to the generalization that the typical one-year-old white infant was "no less than 1.5 cm. taller in 1940 than in 1915" (p. 15). Again, like means at birth were obtained on white infants representing the lower and upper halves of the socioeconomic continuum, but by the middle of the first postnatal year significant social class variation was found. Perhaps the best-controlled example of socioeconomic difference at 1 year of age is that derived from the investigations on infants of northwest European ancestry by Gesell and Thompson [18], Maresh and Washburn [25] and Meredith [27]. The stature mean obtained by Meredith for infants of the professional and managerial classes (1930-39 data) is higher than the combined mean from the other two studies for infants of the middle classes (1927-37 data) by 1.0 cm.

With reference to secular variation, examination of Table 3 shows that the Negro and white means at ages 9 months and 1 year are consistently lower for the period 1910-20 (investigations 1 to 3) than for the period 1930-50 (investigations 4 to 10). The same finding is seen in the stature portion of Table 4 on comparison of the Woodbury study with the other studies.

For each Negro-white comparison within the period 1930-50 (i. e., comparisons 4 through 10 in Table 3, and 2 through 17 in Table 4), there is approximate comparability in economic status and health care. The approximate comparability in economic status has been shown to encompass a small amount of over-all bias, such that the combined Negro groups typify a slightly lower economic level than the white groups. Descriptions of health care, however, leave little doubt that all groups were fed reasonably adequate diets and given sustained medical supervision.

Selected findings from intercomparison of the 1930-50 investigations are as follows: a) the Negro samples of Kelly and Reynolds [22] and Scott, Cardozo, Smith and DeLilly [45] differ economically, differ in mean weight, yet are practically equivalent for mean stature; b) the Negro and white groups studied by Michelson [33] differ relatively little in economic status, but are markedly dissimilar in mean stature and weight; c) during the last half of the first postnatal year the Negro and white samples of Kelly and Reynolds [22] differ appreciably in mean stem length and mean trunk length, although essentially alike in mean stature.

Values from which to derive the most substantial stature and weight generalizations inherent in the 1930-50 data on North American Negro and white infants 3 months to 1 year of age are included in Table 3 (item 9) and Table 4 (item 6). The composite Negro values for weight are based on the Negro samples of investigations 4 through 8 in Table 3, those for stature on the Negro samples of investigations 2 through 5 in Table 4. The composite white values are based on the corresponding white samples, reinforced with 1930-50 data from 6 other North American white studies. The data added represent infants receiving comparably adequate health care, and distributed socioeconomically from the lower classes [4, 15], through the middle classes [25, 37], to the professional and managerial classes [27, 47].

Inspection of the composite values and reference to the samples they portray lead to the generalization: research for the period 1930-50 on

North American Negro and white infants given adequate dietary and medical care shows that during the last half of the first postnatal year the two groups a) do not differ in mean stature, but b) do differ slightly in mean weight, Negroes being the lighter by approximately 0.20 kg, (almost 3 per cent) at 6 months and two-thirds this amount (less than 2 per cent) at 1 year.

SUMMARY

This paper is delimited ontogenetically to the first postnatal year and anthropometrically to 8 measures of body size. Its problem is that of colligating all relevant materials on North American Negroes, and of making comparisons with North American whites.

It is found:

1. The mean weight of viable Negro infants at birth is 3.23 kg. ($N = 39{,}656$), and the mean weight of Negro infants weighing more than 2.2 kg. at birth is 3.28 kg. ($N = 33{,}589$). Corresponding means for white infants are higher by 0.12 kg, and 0.13 kg. respectively. In general terms, the average North American Negro infant is over one-fourth pound, nearly 4 per cent, lighter at birth than the average North American white infant.

2. The mean weight of Negro infants receiving adequate dietary and medical care from birth (1930-50 data) is 7.44 kg. at 6 months ($N = 1{,}831$) and 9.87 kg. at 1 year ($N = 1{,}085$). Comparable means for white infants are higher by 0.20 kg. and 0.13 kg. respectively. It follows that at the end of the first postnatal year the average well-cared-for North American Negro infant is not lighter than the average well-cared-for North American white infant by more than 2 per cent.

3. Stature at birth is shorter for North American Negroes than whites by about 1.0 cm., or 2 per cent. In actual magnitude, the true mean of the newborn Negro infants probably lies between 49.0 cm. and 49.5 cm. Under conditions of adequate dietary and medical care there is no difference in mean stature between North American Negro and white infants after 6 months postnatal age. The means at 6 months and 1 year (1930-50 data) are 66.8 cm. and 75.2 cm., with Negro N's of 704 and 574 and white N's of 3,691 and 2,650.

4. Compared with white infants, Negro infants are smaller in head width, stem length, trunk length, and hip width. This generalization holds for neonates and at later ages throughout the first postnatal year. The definite differences in stem and trunk length during the last half

of the first year, in the absence of a difference in stature, are indirect evidence that the average length of the lower extremities is greater for Negro infants than for white infants.

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THE OXFORD CHILD HEALTH SURVEY: A STUDY OF THE INFLUENCE OF SOCIAL AND GENETIC FACTORS ON INFANT WEIGHT

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THE present investigation is based on the first-year weight records of 298 boys and 282 girls in the Oxford Child Health Survey. Its original purpose was to obtain for this group standards of normal gorwth which allowed not only for age, sex and parity but also for parental size. Subsequently, the standards were used to compare sub-groups defined by social class, feeding habits, sickness experience, etc. Compared with other studies of weight in infancy the number of babies is small, but there are compensating advantages in that each child was seen several times during the first year of life, and that the data include first-hand observation on the parents and homes [Stewart and Russell, 1952].

STANDARDIZATION FOR SEX AND PARITY

The boys in the survey were found, on average, to be 0.32 lb. heavier at birth and to gain 1.34 lb more during the first 12 months. They therefore weighed 1.66 lb. more than the girls at the age of one year. These differences, all of which are significant at the 1 per cent level, have already been discussed [Parfit, 1951]. They indicate the need for separate weight standards for the two sexes and support the recommendation that when birth weight is used as a criterion of maturity, the minimum should be placed lower for girls than for boys [Karn, 1947].

Differences associated with parity were also found to be an important source of variation in birth weight and subsequent weight gain. Thus, the birth weight of first-born babies was distinctly below average but by the end of the year these babies were slightly, though not significantly, heavier than the babies of multiparae. If the tendency for birth weight to increase with parity had merely been due to succeeding pregnancies

normally taking longer, then it would be inappropriate to apply parity corrections, as such, to general standards of infant weight. Gibso· ınd McKeown [1950] have, however, shown that there is no cor. .ıent relationship between parity and length of gestation. It would appear, therefore, that some initial lack of weight, compared with the average for all babies, ought to be regarded as normal in first-born babies, and some excess as normal in babies of high parity. There is, therefore, a case not only for incorporating parity in the present set of weight standards but for advocating parity standardizations in all studies of infant growth.

TABLE 1

The influence of parity and sex on birth weight and weight gain during the first year of life

("Expected" Weights Based on a series of 580 Oxford Babies)

	BIRTH	GAIN 0-12 MONTHS	WEIGHT AT 12 MONTHS
Expected weight (lbs.) of:—			
Male, first born	7.43 (±1.08)*	15.38 (±2.23)	22.81 (±2.46)
Female, first born	7.11 (±1.06)	14.04 (±2.27)	21.15 (±2.44)
Expected deviation (lbs.) from above of:—			
Second born	+0.31	−0.57	−0.26†
Third or later born	+0.45	−0.70	−0.25†

* Figures in brackets are the standard deviations of the weight distributions.

† These deviations are included for the sake of completeness only: they do not differ significantly from zero and have not, therefore, been used in calculating the expected weights used in the paper.

Table 1, which summarizes the information relating to sex and parity was constructed as follows. First, the sex differences for the three sets of weights—birth weight, weight gain between 0-12 months and weight at 12 months—were calculated, and an addition made to each set of girls' weights to convert them to "equivalent boy weights." The sample (boys and girls together) was then divided into first, second and later babies [1] and average weights calculated for these three parity groups in

[1] These parity groups comprised 264, 178 and 134 babies, respectively. Four adopted babies of unknown parity had to be omitted.

terms of "equivalent boy weights." In this calculation it was assumed that parity differences are not influenced by sex. It was allowed, however, that the range of variation of weight might not be the same for boys and girls. There are, therefore, separate standard deviations for the two sexes.

The table shows that if the frequency distributions of weights is normal, and if the survey children are typical, then 95 per cent of first-born girls will weigh between 5.03 lb. and 9.19 lb. at birth, [i. e. $7.11 \pm (1.96 \times 1.06)$]. The same percentage should also gain between 9.59 lb. and 18.49 lb. during their first year [i.e. $14.04 \pm (1.96 \times 2.27)$]. For boys with at least two older siblings the corresponding ranges would be 5.76 to 10.00 lb. for birth weight and 10.31 to 10.95 lb. for weight increment. It will be noted that the survey children have all survived one year of life, and in this respect are not typical of all live births.

STANDARDIZATION FOR SIZE OF PARENTS

In adult life a correlation between the body measurements of parent and offspring is known to exist and it is recognized that this effect must be taken into account before judging the influence of non-genetic factors. It has, however, still to be shown that weight in infancy is influenced by parental size, and following this, that measurements of parents can be used to improve estimates of normal weight in the first year of life. The measures of parental size which have been used in this study are the weight and height of the "mid-parent," as defined by Galton. To obtain these measures the weights and heights of the mothers were first increased by a factor (1.18 for weight and 1.08 for height) which brought the mean for all mothers into line with the mean for all fathers. Then a simple average was taken of the actual measurement of the father and the adjusted measurement of the mother. This is not in fact the most appropriate form of scaling, but it was felt that the material did not justify more elaborate treatment, first because no age-correction for parental weight had been undertaken, and secondly because the measurements of the fathers were not first-hand observations. The mothers were all weighed and measured at the clinic six months after the birth of the child. The fathers' measurements had, however, to be obtained from

questionnaires, and, although there is no reason to suspect that the defaulters were in any way atypical, only 73 per cent of the forms were returned.

TABLE 2

Correlation of infant weight with parental size

B = birth weight
G = gain in weight from birth to 12 months
T = total weight at 12 months
W = average parental weight
H = average parental height

	CORRELATION COEFFICIENTS*		
	Zero order	First order	Total correlation
Birth weight	$r_{BW} = +.223$	$r_{BW.H} = +.160$	$R_{B.WH} = .257$
	$r_{BH} = +.204$	$r_{BH.W} = +.131$	
Weight gain	$r_{GW} = +.393$	$r_{GW.H} = +.356$	$R_{G.WH} = .403$
	$r_{GH} = +.234$	$r_{GH.W} = +.097$	
Weight at twelve months	$r_{TW} = +.415$	$r_{TW.H} = +.323$	$R_{T.WH} = .475$
	$r_{TH} = +.353$	$r_{TH.W} = +.230$	

* Every coefficient in this table is significant at the 0.1 per cent level except $r_{BH.W}$ (1 per cent) and $r_{GH.W}$ (5 per cent).

Table 2 shows the parent-child correlations for the 424 babies for whom a complete set of parental measurements was available. Parental weight proved to have a stronger association with infant weight than did parental height, but even after making allowance for the association between height and weight of the parents ($r_{WH} = +.386$), all the net correlations were statistically significant.

The effect of taking into account the total correlations of birth weight with parental weight and height was to reduce the variance of the birth weights by about one sixteenth ($R_{B.HW} = .257$), and of weight at one year by nearly a quarter ($R_{T.WH} = .475$). It was decided, therefore, before comparing the weight records of different groups of babies, to construct equations for the regression of birth weight, weight gain and weight at one year on parental weight and height. The equations,

expressed in terms of the expected weight of a first-born boy, were as follows:

$$E(B) = 0.0960W + 0.0710H + 1.046$$
$$E(G) = 0.0170W + 0.0526H + 9.118$$
$$E(T) = 0.0428W + 0.270H \quad - 2.524.$$

These equations were then used to obtain the expected mean weights for the seven groups defined in the first column of Table 3. The deviations from expected mean weight are, of course, self-consistent in the sense that the weighted sum of the deviations from any single regression line is always equal to zero. But since the regression of infant weight on parental size was not absolutely stable, the equations are not fully consistent with one another. It follows that the deviations for birth weight and weight gain do not necessarily add up to the deviation for weight at twelve months. It should also be noted that no parity adjustments were made for weight at twelve months because in the present series parity no longer exerted any influence on body weight at this age.

STANDARDIZED WEIGHT COMPARISONS

Before proceeding to a detailed discussion of Table 3 two general cautions are necessary. In the first place, parental measurements were not available for 27 per cent of the babies, and these had to be omitted from the second set of comparisons. Larger deviations from expected weights were therefore needed to establish significance than would have been the case if all the parents had been measured. It follows that while the disappearance in the second set of comparisons of an influence, which is well-marked in the first set, may be the result of standardizing for parental size, it could equally well be the result of using a smaller sample.

The second caution relates to the interpretation of the estimating equations themselves. It is probably adequate to assume that the regression of infant weight on parental size is a measure of genetic influences and that deviations from this line correspond to the effects of environment. But some of the environmental influences which have been studied were shared by the parents and their children, and these, by accentuating family resemblances, may have contributed something to the parent-child correlations. It must, therefore, be borne in mind that the correlation coefficients may have slightly overestimated the importance of genetic factors and slightly underestimated that of environmental factors.

It is for these two reasons—size of sample, and the confounding of

TABLE 3

Standardized weight comparisons

	DEVIATION (LBS.) FROM EXPECTED MEAN WEIGHT, BASED ON SEX AND PARITY				DEVIATION FROM EXPECTED MEAN WEIGHT BASED ON SEX, PARITY AND PARENTAL SIZE			
	No. of babies	Birth weight	Gain 0-12 months	Weight at 12 months	No. of babies	Birth weight	Gain 0-12 months	Weight at 12 months
Social class								
I	31	+.21	−.30	−.06	24	+.22	−.65	−.58
II	58	+.31	+.17	+.41	44	+.24	+.13	+.19
III	385	−.03 †	+.08	−.00 *	289	−.03	+.06 *	+.05
IV	59	−.25	−.52	−.79	41	−.20	−.49	−.58
V	43	+.00	+.03	−.05	26	+.07	+.43	+.56
Total	576				424			
Antenatal health								
Good	440	+.02	−.04	−.01	331	+.02	−.06	−.03
Fair	122	−.00 *	+.14	+.11	83	−.01 *	+.23	+.19
Poor	13	−.68	+.11	−.57	10	−.69	+.07	−.49
Total	575				424			
Toxaemia								
Full term toxaemic	32	−.02	+.17	+.15	23	−.12	+.20	−.07
Non toxaemic	536	+.03	+.01	+.03	394	+.04	+.01	+.05
Total	568				417			
Breast feeding								
Nil	136	−.01	+.44	+.42	98	+.05	+.58	+.62
Some	370	+.00	−.09 †	−.08 †	278	−.01	−.16 ‡	−.17 ‡
Prolonged	70	−.01	−.40	−.43	48	−.07	−.25	−.30
Total	576				424			
Maternal efficiency								
Full marks	502	+.03	+.07 †	+.06 ‡	378	+.02	+.03	+.05
Less than full marks	74	−.22 *	−.48	−.80	46	−.15	−.22	−.38
Total	576				424			
Handicap rating								
0 to 27	493	+.02	+.09	+.11 †	371	+.01	+.02	+.01
28 or worse	83	−.10	−.51 †	−.65	53	−.03	−.15	−.06
Total	576				424			
Sickness rating								
Worst group	36	−.35 †	−.65	+.04 ‡	17	−.18	−.11	−.19
Others	540	+.02	+.04 *	+.07	407	+.01	+.01	−.01
Total	576				424			

The significance tests in this table are all based on the division of total weight variance into components representing sex, parity, parental group and residual differences. The between-group mean square has been compared with the residual mean square and the significance level of the resulting *F*-ratio indicated as follows:—

genetic with environmental factors—that the two sets of standardized comparisons are presented side by side.

(a) *Social Class.*[2] In England and Wales, adult members of the professional and administrative classes tend to be taller and heavier than working class persons. A similar trend was detectable in the Oxford babies at the time of birth, and the inter-class differences were significant at the 5 per cent level. On the other hand, the babies in Social Class II were actually heavier than those in Social Class I, and those in Class V heavier than those in III or IV. Moreover, when allowance was made for parental size the class differences were reduced, and by the end of twelve months it was no longer possible to demonstrate any social gradient. Two factors have probably contributed to this result. In the first place, the parents in Social Class I and II were distinctly heavier and taller than the parents in Social Class III, IV and V, so that the standard weight for their babies was relatively high. Secondly, the babies of working class parents were more often bottle-fed that those in the professional and administrative classes, and for this reason alone they gained more weight in the first year of life (see below).

(b) *Antenatal Health.* Over three-quarters of the mothers enjoyed good health during their pregnancy and only 2 per cent were seriously unwell. The difference in birth weight between the babies of these extreme groups was estimated at 0.70 lb., the lighter babies being born to mothers with poor health. But birth weight differences between three maternal health groups, (good, fair and poor) only reached the 20 per cent level of significance, and in respect of both weight gain and of total weight at twelve months there were no significant differences associated with antenatal health. The introduction of a correction for parental size barely influenced these findings.

A complication arises, however, from the fact that good antenatal health was less common among mothers with four or more children (58 per cent) than among primiparae (84 per cent) or mothers with only two or three children (72 per cent). This means that the tendency for birth weight to increase with parity may have cancelled out to some extent with the tendency for birth weight to decrease with poor antenatal

[2] The population of England and Wales has been divided into five Social Classes (Registrar General, 1931). Class I covers professional and administrative workers, Class III skilled manual workers and Class V unskilled workers. Classes II and IV are intermediate between these three groups.

The significance tests in this table are all based on the division of total weight variance into components representing sex, parity, parental group and residual differences. The between-group mean square has been compared with the residual mean square and the significance level of the resulting F-ratio [illegible]

health. As a result, the net effect of antenatal health on birth weight (and to some extent the effect of parity also) will have been underestimated.

(c) *Toxaemia.* Pre-eclamptic toxaemia was recorded in 40 cases and the birth weight of these babies, after adjustment for sex and parity, was estimated to be 0.39 lb. below standard. In eight cases the condition of the mother necessitated premature delivery, and when these babies were excluded (see Table 3) the estimated birth weight deficit was reduced to negligible proportions (0.05 lb). When allowance was made for parental size the deficit increased again, to 0.16 lb., but this was still insignificant, as were also the estimated differences in gain and in weight at a year. It was not possible to exclude prematurely delivered babies from the control group, but this would only have had a trivial effect on the comparison.

(d) *Breast-Feeding.* Three nutritional groups have been considered: 1) breast-feeding never properly established ('nil'), 2) full breast-feeding maintained for three weeks to five months ('some'), and 3) full breast-feeding continued for more than five months ('prolonged'). These three groups did not differ in respect of birth weight, but differences in weight gain were so marked that, by the end of a year (a period in which even the babies who were breast-fed longest had been weaned for several months) the 'nil' group was estimated to be on the average 0.84 lb. heavier than the 'prolonged' group. When the correction for parental size was introduced, the estimated difference between the 'nil' and 'prolonged' groups remained much the same, but the groups 'nil' and 'some' drew further apart and the differences as a whole reached a higher level of significance. This accentuation of the difference is probably due to the fact that working-class mothers were over-represented in the 'nil' group and under-represented in the 'prolonged' group. Since these women were of smaller than average size, their babies have been compared with a lower standard than that for the survey group as a whole.

(e) *Maternal Efficiency.* During the survey, marks were awarded for 'maternal efficiency' on the basis of a number of subjective assessments concerning the appearance of the household and the child [Thwaites and Sutherland, 1952]. From the first set of standardized comparisons it transpired that, even at birth, the babies born to mothers with less than full marks for maternal efficiency were 0.25 lb. lighter than other babies. By the age of twelve months this difference had increased to 0.86 lb. which is significant at the 1 per cent level. When,

however, parental size was taken into consideration, the estimated differences were almost halved and were no longer of significant magnitude. This result may be due to the smaller sample used in the second set of comparisons, but it also shows that there was a tendency for the small women (who were particularly well-represented in the lower social classes) to receive rather low marks for maternal efficiency, and that this tendency was responsible for much of the superficial association between maternal efficiency and infant size.

(f) *Handicap Rating.* This was a composite score intended to distinguish the mother who enjoyed the best opportunities for child-rearing from those whose commitments or lack of household equipment handicapped them in any way [Stewart and Russell, 1952]. Babies in the most severely handicapped group (13 per cent of the sample) were not distinguishable from other babies at birth, but thereafter they gained significantly less weight and were estimated to be 0.76 lb. lighter than other babies by the age of twelve months. However, poor domestic amenities and/or heavier commitments were most commonly found in the lower social classes and therefore frequently coincided with small parental stature. Because of this, the associated weight differences tended to disappear when parental size was incorporated in the weight standard.

(g) *Sickness Rating.* The sickness rating was a summary measure, designed to select babies whose experience of illness was particularly unfavourable during the first year of life [Stewart and Russell, 1952]. The left-hand side of Table 3 shows that the least fortunate babies (6 per cent) were distinguished at birth by an average weight which was 0.37 lb. lower than that of the remaining 94 per cent of the sample, a difference which is significant at the 5 per cent level. These babies also gained less than average weight so that by the end of the year they were more than a pound lighter than the babies with better health records. Once again, however, the introduction of a correction for parental size caused the estimated weight differences to shrink almost to nothing. The differences for birth weight, for weight gain and for weight at twelve months became one-half, one-fifth, and one-sixth of what they were before.

Unfortunately, the sample of infants with the worst sickness experience contained very few infants with parents of known size, so that the deviations from normal are particularly unreliable. Nevertheless, the contrast between the left and right hand side of Table 3 suggests that part of the association between infant weight and health is due to the

fact that babies who are exceptionally small at birth are more liable to succumb to infections than are larger babies (i. e., the lightness precedes the illness). It would also seem that, whatever their short term effects, acute illnesses do not appreciably retard weight gain over a period of twelve months.

DISCUSSION

The assessment of weight in infancy must always be made by reference to some standard weight, or range of weights, which is thought to be 'normal' for healthy babies of a given age. The crude average weight of a random sample of healthy babies is a useful yardstick for many purposes but it is usually better to have separate standards for boys and girls. In this study two further refinements are suggested.

The allowance for parity was made because the babies of primiparae were lighter at birth and gained more in the first year than babies of multiparae. This allowance would not have been appropriate if the larger gain of first-born babies had been due to their environmental advantages, or if the greater average gain of such babies had been part of a tendency for all initially light babies to gain weight more rapidly than babies who are large at birth. In the survey group, however, there was a slight *positive* correlation between birth weight and weight gain over the first year.

The reason for incorporating parental size into the estimates of expected weight was to distinguish the babies who were constitutionally large or small from the babies who were overweight or underweight as a result of environmental influences. Illingworth (1950) and Parfit (1951) have suggested that, since babies who are relatively light or heavy at birth tend, as groups, to remain light or heavy throughout early childhood, birth weight should be used for this purpose. Their findings certainly show that birth weight reflects some of the constitutional differences in size, but there are theoretical reasons for preferring parental size. To do so not only gets nearer the root of the tendency for large babies to grow into large children, but also has the advantage that it does not set unduly lax standards for the baby who begins life badly, or unduly stringent standards for the baby who begins life well. It also makes possible some assessment of birth weight itself.

Yet in spite of these refinements it is impossible to draw any precise conclusions about the influence of the environmental factors which have been studied. The difficulty was due not to the method of calculating

expected weight but to a failure to obtain for each group of babies defined by parental size, the same cross-section of environmental conditions. Such failure is almost inevitable in social as distinct from laboratory experiments, and in fact most of the effects selected for study were inextricably confounded: antenatal health with parity; maternal efficiency, household amenities and sickness with parental size; and social class with feeding habits.

CONCLUSION

It is suggested that standards of normal weight in infancy should be adjusted for parity and parental size as well as for the sex of the infant concerned. When this was done for a sample of Oxford babies, there was a considerable reduction in the estimated weight differences between certain groups of babies defined by maternal efficiency, home amenities, social class and sickness experience. On the other hand, bad antenatal health still had a measureable effect on birth weight, and breast-fed babies were still found by the adjusted standards to remain lighter than bottle-fed babies at the age of twelve months.

We are indebted to Dr. Jessie Parfit for allowing free access both to the original records of the Oxford Child Health Survey, and to her own calculations.

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